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JOURNAL OF THE AERONAUTICAL SCIENCES

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Gas Pressure Torque of Radial Engines

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(Received August 26, 1938)

SUMMARY

Variations in gas pressure torque on the crankshaft of seven and nine cylinder single row radial engines, and on fourteen and eighteen cylinder double row radial engines are studied by a simplified mathematical analysis combined with empirical indicator diagrams. Actual gas torque curves for these engines are presented together with a complete harmonic analysis of the torques. For the twin row engines with crank throws at 180° the torque analyses for all possible master rod locations are presented and compared.

INTRODUCTION

THE torque acting on the crankshaft of a single cylinder engine due to pressure on the piston varies throughout the cycle because of the variation of gas pressure and also because of the varying relation between crank velocity and piston velocity. If the engine explosions are identical, the gas pressure torque is periodic with two revolutions (for the four-stroke engine). For purposes of computing vibration characteristics of the engine on its mount or for similar studies of the crankshaft-propeller system, it is essential that an expression for the torque be obtained in the form of a Fourier series:

$$T_G = T_M\left\{1 + \sum_{n=1/2,\,1,\,1\frac{1}{2},\ldots}^{\infty} (u_n \cos n\theta + v_n \sin n\theta)\right\}$$

where T_G is the instantaneous torque due to gas pressure, T_M is the mean torque, θ is the crank angle, and u_n and v_n are Fourier coefficients. The coefficients u_n and v_n have been determined for a single cylinder engine operating under a wide range of conditions.[1] From such an analysis the torque of a multi-cylinder engine may easily be found by mathematical summation of the torques from the individual cylinders with their proper phase differences. In a multi-cylinder four-stroke engine with equal crank angles between firing impulses, such a summation results in a new series of the form

$$T_G = T_M\left\{1 + \sum_{n=N/2,\,2N/2,\,3N/2\ldots}^{\infty} (u_n \cos n\theta + v_n \sin n\theta)\right\}$$

where N is the number of cylinders and u_n and v_n are the coefficients determined from the torque of a single cylinder. It will be noted that this torque is periodic with a period equal to that of the explosion impulses.

The radial engine, however, commonly employs a crank mechanism known as the articulated connecting rod. This results in each piston having a motion which differs an appreciable amount from that of any of the others operating on the same crank. It is customary to determine the torque of such engines by means of a graphical layout. In addition to being very laborious, this method has the disadvantage of poor precision. It is the purpose of this paper to present a much more precise and less laborious method using a simplified theory of the articulated connecting rod linkage together with experimentally determined cylinder pressures. Torque curves and harmonic analyses thereof for representative 7, 9, 14, and 18 cylinder radial engines are also presented.

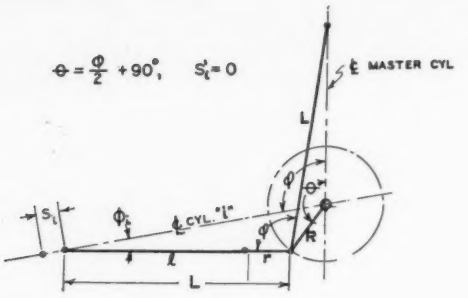

FIG. 1.

PISTON MOTION IN THE SINGLE ROW ENGINE

The position of the piston which is attached to the master rod may be expressed in the form of an infinite series[2]:

$$S_1 = R\{a_0 + a_1 \cos\theta + a_2 \cos 2\theta + a_4 \cos 4\theta + \dots\}$$

$$= R\{a_0 + a_1 \cos\theta + \sum_{n=1}^{\infty} a_{2n} \cos 2n\theta + \dots\} \quad (1)$$

where

S_1 = the displacement of the master piston from its top center position
R = crank radius
L = master rod length (center to center of bearings)
q = R/L
a_0 = $1 + {}^1/_4 q + ({}^3/_{64}) q^3 + ({}^5/_{256}) q^5 + \dots$
a_1 = -1
a_2 = $-[({}^1/_4)q + ({}^1/_{16})q^3 + ({}^{15}/_{512})q^5 + \dots]$
a_4 = $({}^1/_{64})q^3 + ({}^3/_{256})q^5 + \dots$

For normal radial engines q is approximately equal to ${}^1/_4$ thus $a_4 \simeq 0.00024$. This is negligible compared to a_1 and a_2; higher order terms are still smaller.

The position of a piston attached to one of the link rods may be expressed in a form which is convenient for calculation by the addition of a correction term to Eq. (1). If the angle between the master rod axis and the line joining the center of the link pin with the center of the crank pin is equal to the angle φ_i between the axis of the cylinder in question and the master cylinder axis, the correction term S_1' is very closely approximated by

$$S_i' = RQ_i\{1 - \cos(2\theta - \varphi_i)\} \quad (2)$$

where Q_i is a constant to be evaluated later.

To justify this relation, consider the linkage shown in Fig. 1. If the relation $L = l + r$ is maintained (which is true to a sufficient approximation in normal engines) there are two positions of the crank 180° apart in which the crank center is on the extended centerline of the link rod. These crank positions are

$$\theta = (\varphi/2) \pm (\pi/2) \quad (3)$$

At these angles the piston position is the same as it would be with an ordinary connecting rod of length L.

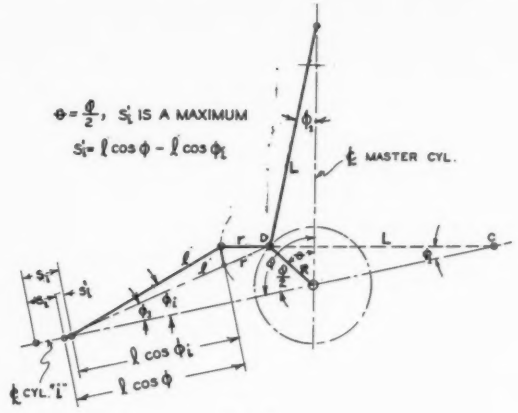

FIG. 2.

At 90° from these positions:

$$\theta = \varphi/2, \quad \theta = (\varphi/2) + \pi$$

S_i' will be nearly a maximum as shown in Fig. 2. When $\theta = \varphi/2$ or $\theta = (\varphi/2) + \pi$, the value of S_i' will be $S_i' = l(\cos\psi_1 - \cos\psi_i)$, where ψ_1 is the angle between the master rod axis and the corresponding cylinder axis and ψ_i is the angle between the link rod axis and the corresponding cylinder axis. (See Fig. 2.)

Also, when $\theta = \varphi/2$ or $\varphi/2 + \pi$,

$$\cos\psi_1 = \sqrt{1 - \sin^2\psi_1} = \sqrt{1 - [(R/L)\sin(\varphi_i/2)]^2} \quad (5)$$

and

$$\cos\psi_i = \sqrt{1 - [(R/L)\sin(\varphi_i/2)]^2\,[(L + r)/l]^2} \quad (6)$$

This latter relation is found by the following construction (Fig. 2): Extend r until it cuts the link rod cylinder axis at C. Then $CD = L$ and

$$l \sin\psi_i = (L + r)\sin\psi_1 \quad (7)$$

The value of Q_i is found from the relation $Q_i = S_i'/2R$ when S_i' is calculated for $\theta = \varphi/2$, therefore

$$Q_i = \frac{l}{2R}\left\{\sqrt{1 - \left(q\sin\frac{\varphi_i}{2}\right)^2} - \sqrt{1 - \left(q\sin\frac{\varphi_i}{2}\right)^2\left(\frac{L + r}{l}\right)^2}\right\} \quad (8)$$

Since R/L is small compared to unity, a binomial expansion of the radicals will give a good approximation for Q_i even though only two terms are included:

$$Q_i = {}^1/_2(1 - \cos\varphi_i)qs + {}^1/_8(1 - \cos\varphi_i)^2 q^3(s + 2s^2) \quad (9)$$

where $s = r/l$

In all modern aircraft engines q and s are very nearly equal to ${}^1/_4$. Substituting these values for the higher order terms:

$$Q_i = (qs/2)(1 - \cos\varphi_i)\{1 + 0.024(1 - \cos\varphi_i)\} \quad (10)$$

and

$$S_i' = R\{(qs/2)(1 - \cos\varphi_i)\}\{1 + 0.024(1-\cos\varphi_i)\} \times \{1 - \cos(2\theta - \varphi_i)\} \quad (11)$$

the value of S_i' computed from the above equation has been compared with measurements on a metal model of an articulated connecting rod system and has been found to check the measured value to better than 2 percent. Since the correction term S_i' is only a small fraction of the total motion, the accuracy of determining the piston position by means of Eqs. (1) and (11) is about ± 0.1 percent. In the ordinary radial engine the value of r is made to vary slightly with the angle φ (about 4 percent) in order to keep the compression ratio constant. The value of r is greatest for the cylinder axes which are inclined nearest 90° from the master cylinder axis. For engines in which r is varied, the piston motions can be obtained by Eqs. (1) and (11) to an accuracy of about ± 0.2 percent. Since elastic deflections are ordinarily considerably more than this figure, the approximation is satisfactory.

A general expression for the motion of *any* piston may now be written, remembering that the crank angle for the cylinder i is $\theta - \varphi_i$:

$$S_i = R\{a_0 + a_1\cos(\theta - \varphi_i) + a_2\cos 2(\theta - \varphi_i) + Q_i + \Delta Q_i - Q_i\cos(2\theta - \varphi_i)\} \quad (12)$$

ΔQ_i is the amount by which r is increased in some cylinders to keep the compression ratio of all cylinders equal; in other words, to make $(S_i)_{max.} = 2R$. Thus, ΔQ_i must be of the proper magnitude to make the bracket term in Eq. (12) fulfill the condition:

$$0 \leqq S_i/R \leqq 2$$

but include both end conditions.

Torque on the Crankshaft Due to Gas Pressure

If a gas pressure crank angle diagram from each cylinder is available, the torque from each cylinder due to gas pressure may be found by equating the rate of doing work on the piston to the rate at which work is done on the crankshaft. The sum of the torques from the separate cylinders is the torque of the engine, τ_P. Thus

$$\tau_P\left(\frac{d\theta}{dt}\right) = \sum_{i=1}^{h} P_i\frac{dS_i}{dt} \quad (13)$$

where P_i = instantaneous indicated cylinder gas pressure and h = number of cylinders in engine.

Indicator diagrams from all cylinders will not always be available, and it will be necessary to approximate the pressures in the link rod cylinders from an indicator diagram of the master cylinder. This may be done by assuming that all cylinders have the same pressure-volume relation. In an actual engine the pressure-volume relation may be different for two reasons: (1) The spark advance for all cylinders is not the same. (2) The mixture distribution may not be equal. It has been shown[1] that over the range to be expected in normal engine operation these variables will have no great influence on the torque curve. Therefore, the assumption of identical pressure volume relations in all cylinders will have little influence on the resultant torque. Such an assumption will fit the ideal case where distribution and combustion are identical in all cylinders.

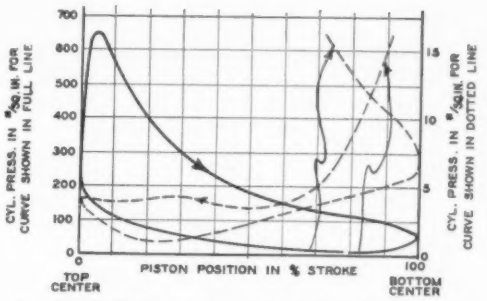

FIG. 3. Cylinder gas pressure as a function of piston position.

Suppose that an indicator diagram taken from the master cylinder is available; since the stroke and compression ratio of all cylinders are equal, the instantaneous pressure in any cylinder is determined by the instantaneous position of the piston. If the pressure from the master cylinder is plotted against the fraction of the stroke $S_i/2R$ (Fig. 3) this diagram may be used for all cylinders.

The instantaneous gas pressure may be substituted in Eq. (13) and the instantaneous torque determined. Calculation of the torque is thus reduced to a routine of tabulation. Experience has shown that computations should be carried out for 10°, or preferably for 5° increments of crank angle, if an accurate curve of torque as a function of crank angle is to be obtained for a seven or nine cylinder engine.* Typical torque curves of seven and nine cylinder engines are shown in Figs. 4 and 6.

Harmonic Analysis of Gas Torque

In order to evaluate the gas torque in numerical terms which will permit the solution of vibration problems and later the extension to two row engines, it is desirable to express the torque due to gas pressure τ_P as a Fourier's series of the form:

$$\tau_P = T_M[1 + w_{1/2}\sin{}^1/_2(\theta + \lambda_{1/2}) + w_1\sin(\theta + \lambda_1) + w_{3/2}\sin{}^3/_2(\theta + \lambda_{3/2}) + \ldots]$$

$$= T_M\left[1 + \sum_{n=1}^{\infty} w_{n/2}\sin[(n/2)(\theta + \lambda_{n/2})]\right] \quad (14)$$

where T_M is the mean torque. The subscripts appear as half integers $n/2$, $2n/2$, $3n/2$, etc., due to the fact

* Detailed computations for a nine cylinder engine may be found in reference 3.

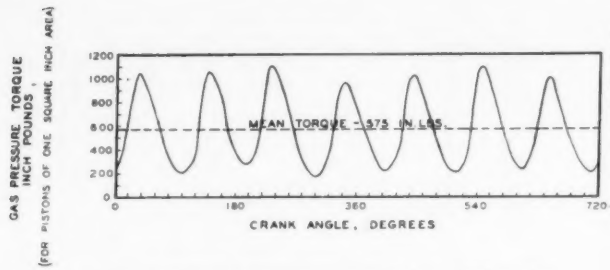

FIG. 4. Gas pressure torque—seven cylinder radial engine.

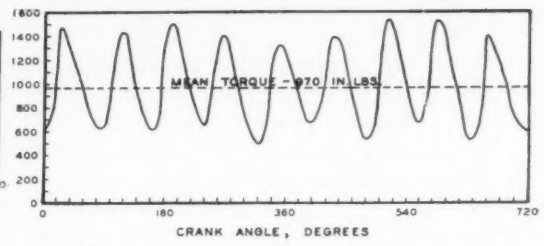

FIG. 6. Gas pressure torque—nine cylinder radial engine.

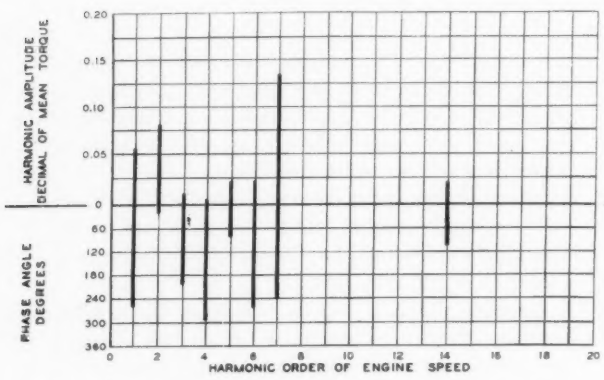

FIG. 5. Harmonic components of gas pressure torque—seven cylinder radial engine.

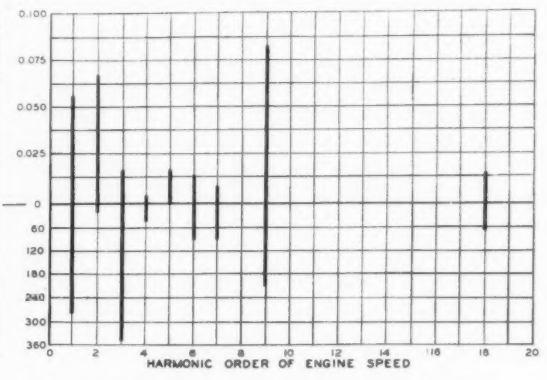

FIG. 7. Harmonic components of gas pressure torque—nine cylinder radial engine.

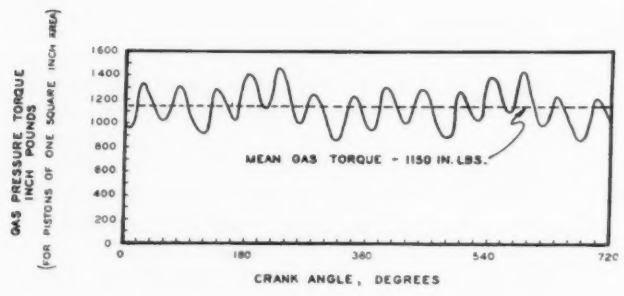

FIG. 8. Gas pressure torque—fourteen cylinder double row radial engine.

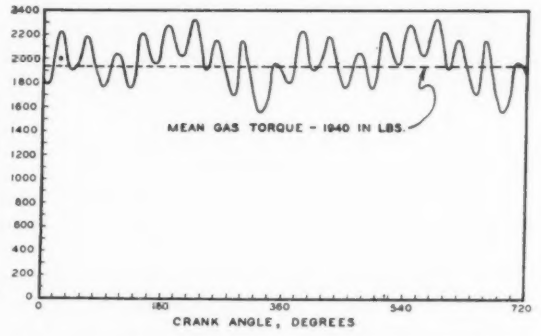

FIG. 10. Gas pressure torque—eighteen cylinder double row radial engine.

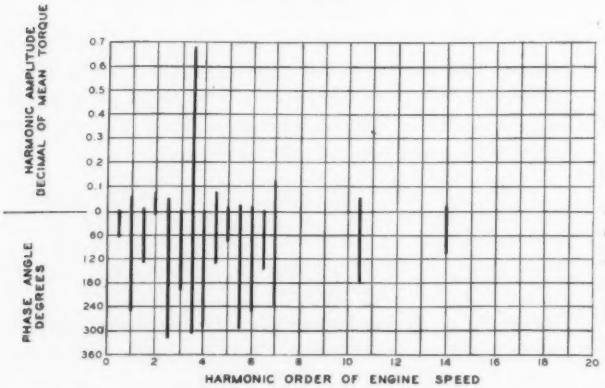

FIG. 9. Harmonic components of gas pressure torque—fourteen cylinder double row radial engine.

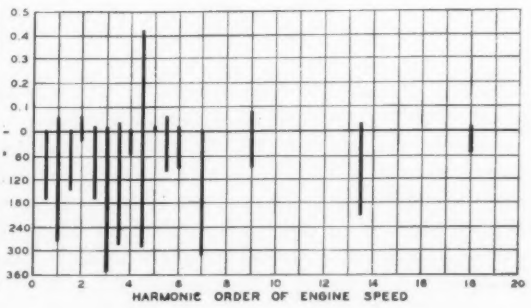

FIG. 11. Harmonic components of gas pressure torque—eighteen cylinder double row radial engine.

TABLE 1

HARMONIC COEFFICIENTS AND PHASE ANGLES

Gas Pressure Torque—14 Cylinder Twin Row Radial Engine—Crank Throws at 180°

Engine Order	n		$\mu = 51°$	$\mu = 462°$	$\mu = 154°$	$\mu = 566°$	$\mu = 258°$	$\mu = 668°$	$\mu = 360$
1	2	w'	0.050	0.035	0.012	0.012	0.035	0.050	0.056
		λ'	281°	306°	332°	178°	204°	229°	255°
2	4	w'	0.047	0.017	0.068	0.068	0.017	0.047	0.076
		λ'	46°	71°	277°	123°	329°	354°	200°
$2^1/_2$	5	w'	0.022	0.040	0.050	0.050	0.040	0.022	0.000
		λ'	346°	11°	217°	243°	89°	115°	...
$4^1/_2$	9	w'	0.034	0.061	0.076	0.076	0.061	0.034	0.000
		λ'	334°	1°	207°	233°	79°	104°	...
7	14	w'	0.134	0.134	0.134	0.134	0.134	0.134	0.134
		λ'	86°	291°	137°	343°	189°	34°	240°
14	28*	w'	0.021	0.021	0.021	0.021	0.021	0.021	0.021
		λ'	131°	336°	182°	28°	234°	79°	285°

* See text for $n = 7$ and $n = 21$.

TABLE 2

HARMONIC COEFFICIENTS AND PHASE ANGLES

Gas Pressure Torque—18 Cylinder Twin Row Radial Engine—Crank Throws at 180°

Engine Order	n		$\mu = 40°$	$\mu = 440°$	$\mu = 120°$	$\mu = 520°$	$\mu = 200°$	$\mu = 600°$	$\mu = 280°$	$\mu = 680°$	$\mu = 360°$
1	2	w'	0.053	0.043	0.028	0.010	0.010	0.028	0.043	0.053	0.056
		λ'	295°	315°	335°	355°	195°	215°	235°	255°	275°
2	4	w'	0.051	0.012	0.034	0.063	0.063	0.034	0.012	0.051	0.067
		λ'	40°	240°	260°	100°	300°	140°	160°	0°	20°
$2^1/_2$	5	w'	0.013	0.020	0.017	0.007	0.007	0.017	0.020	0.013	0.000
		λ'	190°	210°	50°	70°	90°	110°	310°	330°	...
$3^1/_2$	7	w'	0.012	0.023	0.030	0.035	0.035	0.030	0.023	0.012	0.000
		λ'	305°	145°	165°	5°	25°	225°	245°	85°	...
$5^1/_2$	11	w'	0.022	0.041	0.055	0.062	0.062	0.055	0.041	0.022	0.000
		λ'	300°	140°	160°	0°	20°	220°	240°	80°	...
9	18	w'	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
		λ'	50°	250°	90°	290°	130°	330°	170°	10°	210°
18	36*	w'	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
		λ'	75°	275°	115°	315°	155°	355°	195°	35°	235°

* See text for $n = 9$ and $n = 27$.

that the torque cycle of one cylinder is two engine revolutions.

The curves of Figs. 4 and 6 were analyzed by means of a Coradi harmonic analyzer to determine the values of the coefficients w and the phase angles λ. These values are shown graphically in Figs. 5 and 7. The important frequencies are 1, 2, $h/2$, $(h/2) + 1$, $(h/2) - 1$, and h multiplied by engine speed. The coefficients $w_{n/2}$, w_n, $w_{3n/2}$, etc., are within the limits of precision of the computations.

Double Row Engines

The torque due to gas pressure from either bank of a double row engine may be obtained from Eq. (14). The fact that the master rod of the rear row of cylinders may be placed at any of 7 (for a 14 cylinder engine) or 9 (for an 18 cylinder engine) angles with respect to the master rod of the front row makes possible a considerable variation in the torque curve. By merely summing the torques of the two rows with the proper phase angle, the total torque may be obtained

$$\tau_P = T_M \left\{ 1 + {}^1/_2 \sum_{n=1}^{\infty} w_{n/2} \sin \frac{n}{2} (\theta + \lambda_{n/2}) + {}^1/_2 \sum_{n=1}^{\infty} w_{n/2} \sin \frac{n}{2} (\theta + \lambda_{n/2} + \mu) \right\} \quad (15)$$

where μ is the angle between the firing strokes of the two master cylinders and T_M is the total mean torque from both rows. From trigonometric relations:

$$\tau_P = T_M \left\{ 1 + \sum_{n=1}^{\infty} \left(\cos \frac{\mu n}{4} \right) w_{n/2} \sin \frac{n}{2} \left(\theta + \lambda_{n/2} + \frac{\mu}{2} \right) \right\}$$

$$= T_M \left\{ 1 + \sum_{n=1}^{\infty} w'_{n/2} \sin \frac{n}{2} (\theta + \lambda'_{n/2}) \right\} \quad (16)$$

where θ is the crank angle referred to the master cylinder in the front row.

The values of w' and λ' for all master rod positions are shown in Tables 1 and 2 for 14 and 18 cylinder engines. Figs. 8 and 10 are gas pressure torque curves for the cases where $\mu = 2\pi$ for 14 and 18 cylinder engines, respectively. The harmonic coefficients and phase angles are plotted graphically in Figs. 9 and 11 for this special case.

In all double row engines with crank throws at 180° harmonic orders $N/2$, $3N/2$, $5N/2$, etc., where N = total number of cylinders, cancel out between banks. Thus the coefficients for $n = 9, 27$ in the 18 cylinder engine, and $n = 7, 21$ in the 14 cylinder engine become zero and are, therefore, not included in the tables.

Conclusions

(1) In radial engines, in general, the most important harmonic gas pressure torque component is at cylinder explosion frequency. Increasing the number of cylinders decreases the magnitude of this harmonic relative to the mean gas torque approximately in the ratio of the inverse square of the number of cylinders whether of the single or double row arrangement.

(2) In double row engines, the torque components which are not multiples of explosion frequency may be varied widely by changing the relation between the master rods.

(3) The gas pressure torques act on both crankshaft and crankcase. For a complete engine torque analysis, torques due to engine dynamics must be taken into account. The detailed engine dynamic analysis, checked by actual full scale tests, will be presented in an early paper.

(4) Extension of the gas torque analysis to the case of three or more banks of cylinders is readily possible. The critical assumption is that the geometrical shape of the indicator card is identical between engines. Actually, the differences cause but small changes in the important harmonics.

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Effect of Wing Twist upon Stresses Due to Bending

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Summary

In present design practice no attempt is made to calculate the effect of the twisting moment on a wing upon the tensile and compressive stresses due to bending. A simple formula is derived in this article for the ratio of the tensile and compressive stresses under combined simple bending and wing twist to the corresponding simple-bending stresses. This formula involves an unknown constant which must be obtained experimentally from a deflection test on the wing.

Introduction

IN THE design of stressed-skin wings it is customary to divide the resultant moment on the wing into two components, one causing simple bending and the other pure torsion (so-called). The simple-bending moment is obtained by placing the load at the elastic center of the cross-section on which it acts, while the so-called pure-torsion moment results from taking the sum of the moments of each force about the elastic center of the cross-section on which it acts. The tensile and compressive stresses due to bending are calculated from the simple-bending component and the torsional shearing stress from the pure-torsion component. But in present design practice no attempt is made to calculate the effect of the pure-torsion component on the bending stresses.

The first correct analysis of the bending stresses in a rectangular box-beam due to torsion was made by Reissner.[1] He analyzed a rectangular box-beam without corner flanges. A more comprehensive treatment, which includes Reissner's solution as a special case, was later made by Ebner.[2] Since Ebner's formulae for a rectangular box-beam are rather cumbersome, the corresponding formulae for an airplane wing, if they could be found, would probably be too involved for ordinary design purposes. For this reason, it might be desirable to employ some other attack than theory alone.

Fundamental Assumption

Let X_0 be any point on the intersection with the wing root of one of the flanges of a shear web of the wing, and let s_0 be the tensile or compressive stress at X_0 due to bending. The fundamental assumption is that when such a shear web is always at the same percentage of the chord from the leading edge of the wing, as is usually the case, s_0 will be proportional to the deflection of point X, where X is the point on the loaded cross-section of the wing corresponding to point X_0 on the root section, regardless of whether this deflection is due entirely to simple bending or partially to simple bending and partially to wing twist. Obviously, this assumption has to do with a single loaded cross-section of the wing. When every cross-section of the wing is loaded, as is generally the case, an averaging process must be employed, as will be explained later.

Stress Equations

Let S be the loaded cross-section of the wing, and let δ with a double subscript be the deflection at a point on S represented by the first letter of the subscript when the resultant load on S is at the point represented by the second letter of the subscript. For example, δ_{XZ} is the deflection at point X on S when the resultant load on S acts at point Z. Let δ_E be the deflection of the elastic center of S, and let s_b and s_{bt} be the tensile or compressive stress at point X_0 due, respectively, to simple bending and combined simple bending and wing twist. From the fundamental assumption, s_{bt} is proportional to δ_{XZ}. But if the resultant load on S causes simple bending only, $\delta_{XZ} = \delta_E$ and hence s_b is proportional to δ_E. Therefore,

$$s_{bt}/s_b = \delta_{XZ}/\delta_E \tag{1}$$

Let x and z be the distances in inches along the chord of S to points X and Z, respectively; and let x and z be positive when X and Z, respectively, are forward of the elastic center of S. If z is held constant, $(\delta_{XZ} - \delta_E)$ varies as x; while if x is held constant, $(\delta_{XZ} - \delta_E)$ varies as z. Hence, in general, $(\delta_{XZ} - \delta_E)$ varies as the product xz. It will be convenient to write

$$\delta_{XZ} - \delta_E = (x/c)(z/c)k\delta_E \tag{2}$$

in which c is the chord of section S in inches and k is a constant of proportionality. Obviously,

$$\delta_{XZ}/\delta_E = 1 + (x/c)(z/c)k \tag{3}$$

Hence, from Eq. (1)

$$s_{bt}/s_b = 1 + (x/c)(z/c)k \tag{4}$$

Note that when the resultant load is at the elastic center of S (simple bending), $z = 0$ and Eq. (4) reduces to $s_{bt} = s_b$.

Determination of Experimental Constant

As will be shown later, the constant k in Eq. (4) can be found from a deflection test of the wing with a test

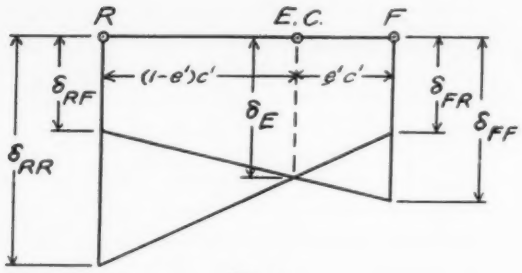

FIG. 1.

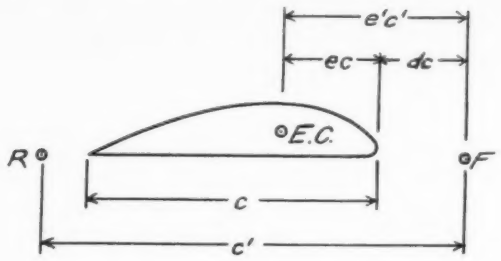

FIG. 2.

load placed at cross-section S. Since the value of k so obtained might be different for each cross-section tested, an average value of k must be found for the entire half wing when the wing has a distributed load upon it. A reasonable average value of k should result from placing the test load at the wing section upon which the resultant load on the half wing acts. The value of z in Eq. (4) would then be the distance from the resultant force to the elastic center of the cross-section on which the resultant acts. Probably, a sufficiently accurate average value of k can be found by placing the test load on the wing section through the aerodynamic center of the half wing, because the spanwise location of the resultant of the aerodynamic and inertia forces on a half wing should be very close to the aerodynamic center of the half wing. Then z in Eq. (4) would be the distance from the aerodynamic center of the half wing to the elastic center of the cross-section containing the aerodynamic center.

It may not be possible to calculate beforehand this average value of k for a wing which has not yet been built. But this difficulty will be overcome when sufficient data has been collected from tests on actual wings to enable a designer to estimate k beforehand. Hence it should be possible in the future to use Eq. (4) in the design of airplane wings.

Deflection Formulae

The value of k for any cross-section depends upon the location and deflection of the elastic center of that cross-section, both of which can be found experimentally by means of a deflection test. In Fig. 1 the first letter of the subscript tells where the deflection is to be taken and the second letter tells where a load of magnitude P (which may have any value desired) is to be placed when that deflection is to be measured. For example, δ_{FR} is the deflection of point F when load P is at point R. Note that from Maxwell's Theorem of Reciprocal Deflections, $\delta_{RF} = \delta_{FR}$.

The deflection δ_E at the elastic center of this loaded cross-section is the same no matter where load P is placed. Hence both δ_E and the position of the elastic center correspond to the intersection of the two diagonal straight lines shown in Fig. 1. If c' is the distance between points F and R and e' is the distance point F is in front of the elastic center as a fraction of c', it can be shown from the geometry of Fig. 1 that

$$e' = (\delta_{FF} - \delta_{FR})/(\delta_{FF} + \delta_{RR} - 2\delta_{FR}) \tag{5}$$

$$\delta_E = (1 - e')\delta_{FF} + e'\delta_{RF} = e'\delta_{RR} + (1 - e')\delta_{FR} \tag{6}$$

If points F and R in Fig. 1 are not at the leading and trailing edges of the loaded cross-section, it is easier to find first a constant k' defined by the relation (see Eq. (3))

$$\delta_{XZ}/\delta_E = 1 + (x/c')(z/c')k' \tag{7}$$

To find k', substitute in Eq. (7) the first value of δ_E in Eq. (6) and replace δ_{XZ} by δ_{FF} and both x/c' and z/c' by e', or substitute in Eq. (7) the second value of δ_E in Eq. (6) and replace δ_{XZ} by δ_{RR} and both x/c' and z/c' by $(e' - 1)$. Then

$$k' = (\delta_{FF} - \delta_{RF})/(e'\delta_E) = (\delta_{RR} - \delta_{FR})/\{(1 - e')\delta_E\} \tag{8}$$

These two values of k' are consistent because when they are equated, the value of e' given in Eq. (5) is obtained. Since Eqs. (3) and (7) must yield the same value of δ_{XZ},

$$k = (c/c')^2 k' \tag{9}$$

Let d be the distance of point F from the leading edge as a fraction of the chord c, and let d be positive when F is forward of the leading edge. Then from Fig. 2 the distance e of the elastic center from the leading edge as a fraction of the chord c will be

$$e = (c'/c)e' - d \tag{10}$$

If preferred, e' can be found experimentally by locating the point of zero deflection on the cross-section when a pure torque is applied to the cross-section. If e' is found in this manner, δ_E can be obtained from Eq. (6) and k' from Eq. (8) from either δ_{FF} and δ_{RF} or δ_{RR} and δ_{FR}.

Stresses between Shear Webs

Our present knowledge of the effect of shear lag between shear webs is very limited. One of the first contributions on this subject was made by Kuhn.[3] Additional work along this line has recently been done by Reissner.[4] With the start given by these two men, it should be possible at some future time to find the stresses at stiffeners between shear webs when the

stresses at the shear webs are known. But until that is accomplished, it might be desirable to use Eq. (4) for stiffeners between shear webs as well as for stiffeners which form part of the shear webs themselves. If this is done, point X, from which x in Eq. (4) is found, is a point on the loaded cross-section with a location similar to the point X_0 at the wing root for which the ratio s_{bt}/s_b is desired.

Example. Consider a tapered wing of two-spar construction with its spars always at 15 percent and 65 percent of the chord, respectively, from the leading edge and with the moment of inertia of the front spar at each wing section always 1.5 times the corresponding moment of inertia of the rear spar; and let the torsional resistance of this wing be due entirely to the bending resistance of the spars. Suppose that the tensile and compressive stresses at the root of the front and rear spars are wanted for a resultant normal load P at 20 percent of the chord back of the leading edge. If F stands for the front spar and R for the rear spar, $\delta_{RR} = 1.5\ \delta_{FF}$. Moreover, $\delta_{FR} = \delta_{RF} = 0$, because there is no deflection at either spar when the load is at the other spar. Note that c'/c in Eqs. (9) and (10) is $(0.65c - 0.15c)/c = 0.5$, while d in Eq. (10) is -0.15 because F is 15 percent of the chord behind the leading edge. Hence from Eqs. (5), (6), (8), (9), and (10), respectively,

$$
\begin{aligned}
e' &= (\delta_{FF} - 0)/(\delta_{FF} + 1.5\ \delta_{FF} - 2 \times 0) = 0.4 \\
\delta_E &= (1 - 0.4)\delta_{FF} + 0.4 \times 0 = 0.6\ \delta_{FF} \\
k' &= (\delta_{FF} - 0)/(0.4 \times 0.6\ \delta_{FF}) = 25/6 \\
k &= (1/0.5)^2 \times 25/6 = 50/3 \\
e &= 0.5 \times 0.4 - (-0.15) = 0.35
\end{aligned}
$$

Hence, from Eq. (4),

$$
\begin{aligned}
s_{bt}/s_b \text{ (front spar)} &= 1 + \\
&\quad (0.35 - 0.15)(0.35 - 0.2)50/3 = 1.5 \\
s_{bt}/s_b \text{ (rear spar)} &= 1 + \\
&\quad (0.35 - 0.65)(0.35 - 0.2)50/3 = 0.25
\end{aligned}
$$

These values of s_{bt}/s_b can also be found from an ordinary two-spar analysis, as follows. If P were at the elastic center ($0.2c$ from front spar and $0.3c$ from rear spar), the loads carried to the two spars would be $0.6P$ to front spar and $0.4P$ to rear spar. But with P at 20 percent of the chord behind the leading edge ($0.05c$ from front spar and $0.45c$ from rear spar), the loads carried to the two spars are $0.9P$ to front spar and $0.1P$ to rear spar. Since the stresses at the wing root of a given spar are proportional to the loads on that spar, the ratios of s_{bt} to s_b at the spar roots when P is at 20 percent of the chord behind the leading edge are:

$$
\begin{aligned}
s_{bt}/s_b \text{ (front spar)} &= 0.9P/0.6P = 1.5 \\
s_{bt}/s_b \text{ (rear spar)} &= 0.1P/0.4P = 0.25
\end{aligned}
$$

Hence stresses obtained from Eq. (4) are valid for a two-spar wing, which certainly is a necessary (but not sufficient) condition for any formula which is claimed to be applicable to wings in general.

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Possibilities of the Jump-Off Autogiro

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Introduction

THE direct take-off described herein involves the use of kinetic energy stored in a rotor revolving at high speed. If the rotor blades are set at zero lift incidence when the rotor is being accelerated there will be no lift, downwash, or induced drag; consequently the power required for accelerating the rotor will be reduced. Further, if the incidence angles of all blades in a rotor system are suddenly and simultaneously increased from the angle of attack of no lift to a proper lifting angle of attack when the rotor is revolving at twice its normal rotational speed, the aircraft will be lifted off the ground. The stored energy will be great enough to continue lifting the ship to a height above tree tops and it will have sufficient forward speed for continued climb.

In the usual application of propellers and helicopters, the air flow of translation passes through the disc opposite to the direction of thrust, but in autorotating wing aircraft the airflow of translation passes through the disc in the direction of thrust. Thus it is apparent that autorotating wing aircraft cannot be directly compared with helicopters for vertical ascension as long as the blade incidence angles remain at normal autorotative angles. However, if it is assumed that the blade incidence angles can be increased above as well as decreased below autorotative angles, then a direct comparison is in order. When the ship leaves the ground, it is acting as a "free-wheeling" helicopter and when the stored kinetic energy has been absorbed, it is acting as a giro. Calculations indicate that the available power during the "free-wheeling" helicopter action may likely be five times as great as is necessary for sustentation as a helicopter. This accounts for the rapidity at which altitude may be gained during the jump take-off.

E. P. Warner,[1] gives theoretical optimum values of horsepower required for helicopters based on rotor diameter, rotor r.p.m., power loading, and disc loading. These data have been reduced to a simple plot of power loading *vs.* disc loading using optimum values as shown on Fig. 4.

R. N. Liptrot[2] gives explanations and figures of about ten helicopters which have been able to leave the ground. A plot of power loading *vs.* disc loading for these helicopters is shown on Fig. 4. The accuracy of Warner's theoretical figures is clearly demonstrated by the distribution of actual helicopter power loadings and disc loadings plotted along this curve. With the disc loading known, the power loading required for sustentation may be obtained from Fig. 4. The horsepower, s required to sustain a given helicopter would be the gross weight divided by the power loading indicated, $s = W/Power\ Loading$.

The kinetic energy of the rapidly revolving rotor could be dissipated at a rate which is just sufficient to keep the craft in sustentation without lifting it vertically; however, when the dissipation of the stored kinetic energy is greater, the ship will rise vertically. The energy required for sustentation is $E_s = 550st$ ft. lbs.

The energy required for vertical translation is equivalent to the weight of the ship times the vertical distance of translation, $E_t = Wh$.

The total dissipated energy is $E_s + E_t$.

The excess kinetic energy, K.E., available for jump-off is given by K.E. $= I(\omega^2 - \omega_0^2)/2$ (the values of ω and ω_0 may be calculated from Eqs. (3) and (6), respectively).

Equating the dissipated energy and the excess kinetic energy,

$$[I(\omega^2 - \omega_0^2)/2 = E_s + E_t] \qquad (1)$$

For rectangular blades having uniform weight distribution, $I = bMR^2/3 = bpR^2/3g$.

Substituting the above values for I, E_s, and E_t in Eq. (1) gives a simple formula for estimating the height of jump-off when uniform blades are used.

$$bpR^2(\omega^2 - \omega_0^2)/6g = 550st + Wh$$
$$h = [bpR^2(\omega^2 - \omega_0^2) - 3300stg]/6gW \qquad (2)$$

The above equation is based on obtaining optimum angles of incidence of the blades during the jump take-off.

Formulas

Following are the notations used:

- a = Increment of velocity after passing through disc.
- α = Total angle between the plane of rotation and the zero lift line of the blade in degrees.
- α_L = Lift angle of attack of blade in degrees.
- b = Number of blades comprising rotor.
- C = Blade chord in ft.
- C_{D_0} = Drag coefficient of blade at zero lift.

C_D = Drag coefficient of blade at given angle of attack.
g = Gravitational acceleration in ft. per sec.^{2}
h = Height of jump in feet.
I = Moment of inertia of rotor in slug ft.^{2}
K = Slope of lift curve ($dC_L/d\alpha$).
λ = Load factor of rotor thrust (T/W).
θ = Angular deceleration of rotor in rad. per sec.^{2}
p = Weight of individual blade having uniform distribution in lbs.
ρ = Air density.
Q = Rotor torque in ft. lbs.
R = Blade radius in ft.
s = Horsepower required for sustentation at given vertical acceleration.
σ = Solidity of rotor ($Cb/\pi R$ for rectangular blades).
T = Rotor thrust in lbs.
t = Time in seconds.
V_v = Velocity normal to disc (at the disc) in ft. per sec.
V_T = Vertical translational velocity of giro in ft. per sec.
W = Gross weight of autogiro in lbs.
ω_0 = Flight rotor speed in rad. per sec.
ω = Rotor speed in rad. per sec.

While Eq. (2) gives an approximation of height of jump-off for various values of accelerated jumps dependent upon the time t required for the jump, it does not give important design information such as blade angles during the maneuver. The following equations may be used for determining the blade angles and more accurately determining the height of jump.

1. *Power Required to Accelerate Rotor*

With reference to Fig. 1, consider the element of area Cdr where the velocity is ωr, the equation of drag becomes:

Δ Drag on area $Cdr = C_D\rho\ Cdr\ (\omega r)^2/2$
$\Delta Q = \Delta$ moment about axis $P = C_D\rho\ Cdr\ \omega^2 r^3/2$

The horsepower required for the rotor is proportional to the number of blades b composing the rotor and the torque ΔQ. h.p.$_r = \omega \Delta Q b/550$. Substituting ΔQ,

$$\text{h.p.}_r = [C_D\rho Cb\omega^3/1100]\int_0^R r^3 dr$$

Therefore the horsepower required to accelerate a given rotor to a speed of ω radians per sec. is hp.$_r$ = $C_D\rho Cb\omega^3R^4/4400$.

For rectangular blades, the solidity σ of the rotor is equal to $Cb/\pi R$. Substituting for the non-dimensional term solidity in the above equation, the horsepower required to accelerate a rotor becomes

$$\text{hp.}_r = C_D\rho\sigma\pi\omega^3R^5/4400 \qquad (3)$$

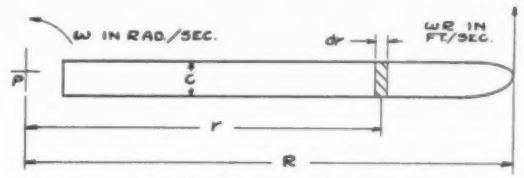

FIG. 1. Plan view of blade.

2. *Initial Lift and Load Factor*

The following equations give the initial lift and load factor imposed on the giro, neglecting downwash and circular rotation. The angle of attack in degrees may be expressed in terms of lift coefficient when the slope of the lift curve, K is known.

Referring again to Fig. 1, the lift on area Cdr is $dL = dT = K\alpha_L\rho Cdr(\omega r)^2/2$. Integrating and substituting $\sigma = Cb/\pi R$,

$$T = K\alpha_L\rho\pi\sigma\omega^2R^4/6 \qquad (4)$$

The initial load factor, λ_0, will be half the calculated initial rotor thrust divided by the gross weight of the autogiro in accordance with the Wagner theory, which shows that a blade acting instantaneously on still air develops only half the calculated force.

$$\lambda_0 = K\alpha_L\rho\pi\sigma\omega^2R^4f/12W \qquad (5)$$

where f represents the increase in λ_0 due to ground effect.

Eq. (4) may also be used for determining the autorotative or optimum rotor speed for autogiro or helicopter in vertical descent when transposed as follows:

$$\omega_0 = \sqrt{6W}/R^2\sqrt{\alpha_L K\rho\pi\sigma} \qquad (6)$$

In this form, the only unknown is $K\alpha_L$ whose value varies with blade incidence angle, aspect ratio, and airfoil characteristics. As an approximation, the value of $K\alpha_L$ may be taken as 0.75.

3. *Lift during Ascent*

The following calculations give the lift on an autogiro or helicopter ascending vertically taking into account the vertical velocity of the craft and the slip or downwash. The relationship between the component of velocity which is normal to an element of the disc, V_v, and the component of velocity which is in the plane of rotation at the same element, V_H, expresses the induced angle at the blade element in question.

Referring to Fig. 1, $V_H = \omega r$ (velocity of blade element in plane of rotation) and $V_v = V_T + V_D$ where V_T is the vertical translational velocity of the craft (negative when the craft is ascending) and V_D is the downwash velocity at the disc, being negative under practical circumstances. It is assumed that the value of V_v remains constant over the entire rotor disc at a given time. The total velocity of the blade element is $\sqrt{V_H^2 + V_v^2}$. For simplicity the effect of the vertical velocity component V_v on the velocity over a blade

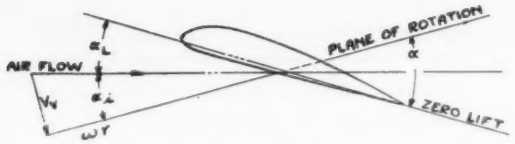

FIG. 2. Section of blade element.

element is neglected. The induced angle of attack of the blade element is $57.3\ V_v/\omega r$.

The total thrust on the disc is

$$T = (b\rho C\omega^2/2)\,[K\alpha \int_0^R r^2 dr + (57.3\ KV_v/\omega) \int_0^R r dr]$$

in which the total thrust coefficient at a section of the blade is represented by $K(\alpha + 57.3\ V_v/\omega r)$.

Integrating and introducing the solidity factor σ,

$$T(\text{lbs.}) = \pi\rho\sigma K(\alpha R^4\omega^2/6 + 57.3\ V_v R^3\omega/4) \quad (7)$$

The value of K represents the slope of the lift curve for infinite aspect ratio since the downwash factor has already been considered in the value of V_D. For normal airfoils the value of K may be taken as 0.10. The value of α is the total blade angle from zero lift to the rotor disc measured in degrees (see Fig. 2).

4. *Deceleration of Rotor during Ascension*

There are two components of drag, profile and induced, which decelerate the rotor during ascension. The profile-drag C_{D_0} is assumed to act along the airflow line at an angle α_i to the plane of rotation. Since these angles are small, both the induced and profile drags may, without sensible error, be considered as acting in the plane of rotation.

The induced-drag coefficient C_{D_i} is equal to the lift coefficient $K\alpha_L$ multiplied by sin α_i. Calling sin $\alpha_i = \alpha_i = V_v/\omega r$, $C_D = C_{D_0} + K\alpha_L V_v/\omega r$.

Referring to Fig. 1, $dQ = C_D C\, dr\rho\omega^2 r^3/2$. Substituting the value for C_D given above, integrating, multiplying by the number of blades, and introducing the solidity factor, σ,

$$Q = \pi\sigma\rho[C_{D_0}R^5\omega^2/8 + K\alpha_L V_v R^4\omega/6] \quad (8)$$

The horsepower absorbed is hp. $= \omega Q/550$ and the deceleration of the rotor is given by

$$Q = I\theta \text{ or } \theta = Q/I \quad (9)$$

METHOD OF USING EQUATIONS

There appears to be no direct method of solving Eqs. (7) and (8) and, therefore, a trial-and-error method must be utilized. The following steps were used in evaluating the predicted results given herein.

(1) From the available power and rotor characteristics, calculate maximum rotor speed at start of jump from Eq. (3).

(2) Determine normal rotor speed in flight from Eq. (6).

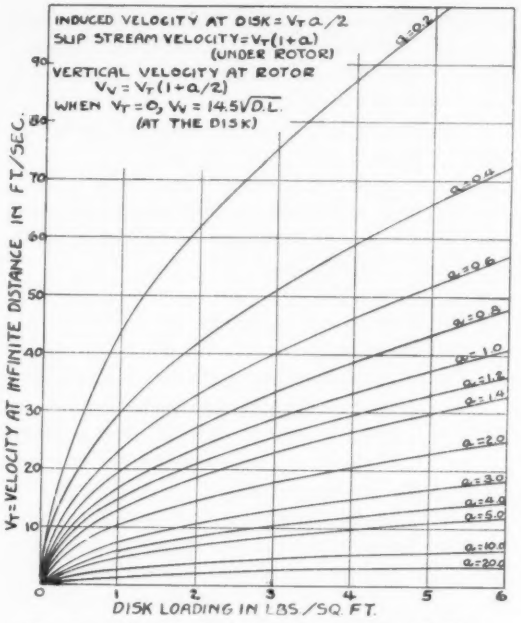

FIG. 3. Induced velocity factors at plane of disc.

(3) Calculate the approximate height of the jump from Eq. (2), substituting several values for t.

(4) With the approximate height of jump and time known, calculate necessary accelerations to obtain height h in time t. Select a set of calculations which give reasonable accelerations and re-check h using values of s corrected for actual disc loading based on accelerations.

(5) Plot curve of altitude accelerations, and vertical velocity against selected time in seconds.

(6) Knowing the acceleration, the initial and subsequent values of α_L may be determined from Eq. (4) and substituted in Eq. (8).

(7) Knowing the vertical accelerations, the values of vertical translational velocity and disc loading may be calculated from the equations of rectilinear motion and plotted against time. At selected intervals of time, the values of V_v may then be determined from Fig. 3 and substituted in Eqs. (7) and (8). This leaves the value of torque Q of Eq. (8) dependent only on the one unknown, rotor speed ω for increments of the jump. (The values shown on Fig. 3 are plotted from the following form of the momentum equation: *Disc Loading* $= V_T^2\rho a(1 + a/2)$.)

(8) The rotor speed at the start of the jump is known; therefore, the initial deceleration of the rotor may be determined from Eq. (9).

(9) At the end of a selected interval of time (using the initial deceleration of the rotor), a new rotor speed is determined which may again be substituted in Eqs. (7) and (8) along with the calculated values of V_v and thrust T.

(10) If, at the end of the calculations, the rotor speed ω is greater than free-flight rotor speed, the time

t should be extended and, therefore, the height of jump would be greater than assumed and, conversely, if the rotor speed is less than free-flight rotor speed the time t must be reduced and, therefore, the original approximated height of jump must be reduced.

Predicted Results

By utilizing the equations developed herein, the author has made calculations of the height of jump, horizontal distance traversed, time for maneuver, initial acceleration, and maximum blade-pitch angle involved during the jump for several different types of machines incorporating varying degrees of ideal jump take-off equipment. In each case, with exception of the first, it is assumed that the rotor axis is kept vertical during the jump. Furthermore, it is assumed that the engine propeller is producing full-throttle thrust which is accelerating the ship forward during the jump. The values are arranged in Table 1.

Conservative Factors in Calculations

There are three factors not considered in the equations developed in this paper which make the results conservative.

(1) At the instant the blade-pitch angles are increased at the initial stages of the jump, the flow down through the rotor disc is zero; therefore, the initial induced drag on the blade elements and dissipated energy is reduced.

(2) Up to an altitude of approximately one rotor diameter, ground effect is present. This ground effect tends to reduce the induced flow down through the rotor from the theoretical values as determined from the momentum equation and, therefore, reduce the power input for a given lift.

(3) Since the equations are based on vertical ascension, any forward speed obtained during the jump will reduce the induced drag.

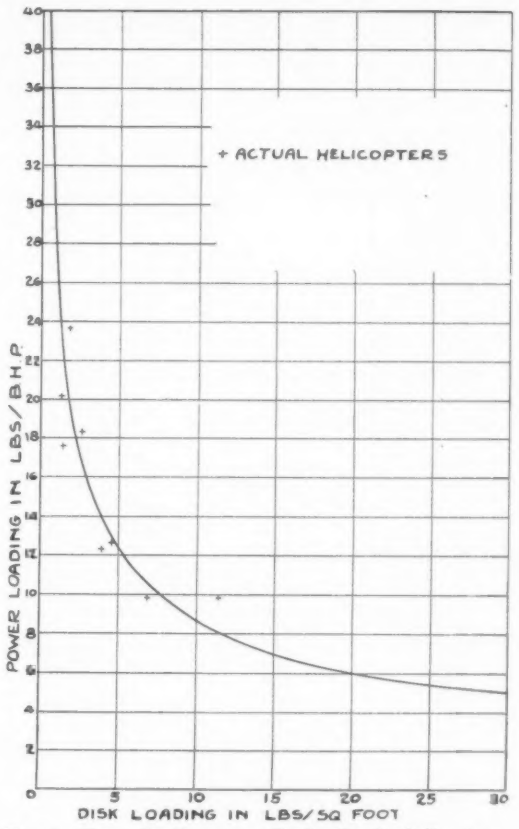

Fig. 4. Power loading *versus* disc loading for helicopters.

Conclusions

(1) It appears that all-purpose autogiros can be built to "jump-off" up to 100 feet and that for special purposes, autogiros can be made to "jump-off" 200 feet. In the former case, the gross weight of the ships will be increased less than 5 per cent to account for the increase in blade weight and extra mechanism involved and in the latter case, the gross weight will be increased less than 15 per cent for the same items. It is believed that

Table 1

Ship	Propeller	Limits of Rotor Blade Angles	Height of Jump	Horiz. Dist.	Time in Seconds	Initial Acceleration Ft./Sec.^{2}
1	Fixed	0–5°	Direct take-off	..	..	..
2	Fixed	0–15°	40 ft.	25 ft.	2.5	35
3	Controllable	0–20°	75	34	3.8	40
*4	Controllable	0–30°	225	55	4.2	60

* Ship No. 4 differs from the other ships in that the rotor blades are considerably heavier than on ships 1, 2, and 3. Furthermore, the controllable propeller for ship No. 4 is adjustable to an angle of attack of minimum power absorption so as to provide the maximum engine power for the rotor. The values given in the above table are graphically illustrated in Figs. 5 and 6.

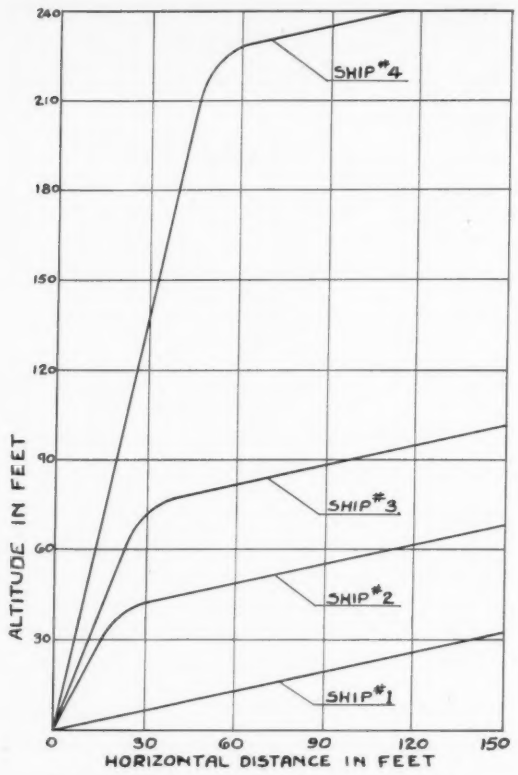

FIG. 5. Flight paths of autogiros in still air.

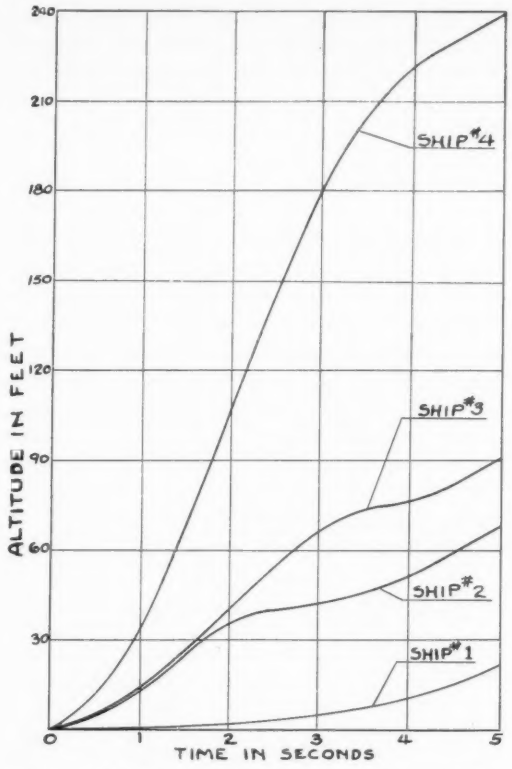

FIG. 6. Altitude *versus* time for representative autogiros.

the accelerations involved in the above predictions will not be excessive.

(2) The available kinetic energy in the rotor system for "jump-off" is directly proportional to the weight of the blades and to the square of the rotational speed of the rotor. Thus, with a given autogiro having the weight of the blades fixed, the height of "jump-off" is dependent upon the horsepower available for accelerating the rotor. This in turn, is dependent upon the pitch setting of the propeller which, for relatively high jumps, would have to be of controllable type to provide adequate power for the rotor and yet hold down the engine r.p.m. at top speed. Fig. 7 shows the variation of power absorbed by the propeller for changes in pitch setting.

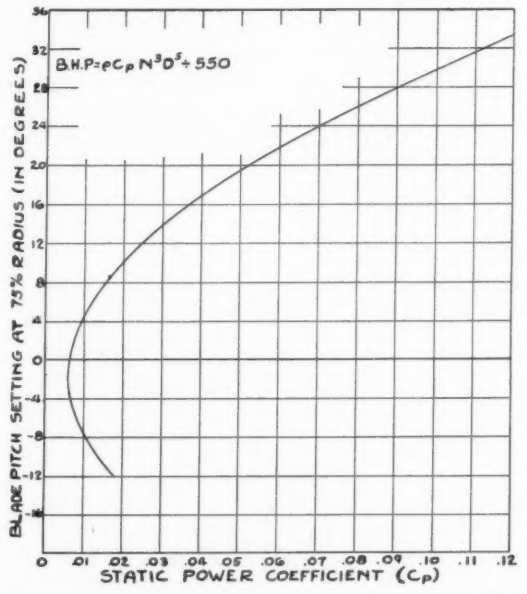

FIG. 7. Static power coefficient of propeller *versus* blade angle at 75 percent of radius.

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Desirable Qualities of Transport Airplanes from the Pilot's Point of View

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Introduction

IN DESIGNING modern transport equipment, the engineer is confronted with so many structural and aerodynamic problems that often some of the operating complications are either overlooked or underestimated.

In this paper an attempt will be made to outline briefly a few of the many circumstances and airplane characteristics that either help or hinder the schedule pilot in the safe and satisfactory discharge of his duties.

In the final analysis, regardless of the excellence of the design from an economic standpoint, the safe completion of the trip is likely to depend on the least capable of a possibly large group of pilots flying the particular model ship. It is when this weakest pilot and the worst operating conditions meet that the design may become critical. The difference between a highly complicated airplane and one that is easy to fly and simple to operate could easily mean the difference between the normal completion of a trip and the opposite. This, particularly, applies to the period during which the pilot is becoming familiar with the ship, possibly from six months to two years, depending upon the pilot and the number of differences between the new ship and the one which he has been flying. Becoming thoroughly familiar with a new ship is rather a complex task as may be seen in the following discussion.

A well-known psychiatrist recently stated that there was more to do in the cockpit of a modern air transport than could be reasonably expected of any human.

There are many forms of activity that are comparable to the pilot's problem. A stenographer's mind picks up the words and her fingers instinctively operate the keys of her typewriter. One can easily imagine the drop in her efficiency and the increase in mistakes if her keyboard were changed periodically, even considering that the re-arrangements were improvements. A pilot has many more keys to operate than a stenographer, and his mistakes are much more costly.

One of the major airlines recently acquired a number of new low wing bimotored transports to supplement their fleet of similar, though somewhat smaller planes. The only basic difference between the two types was the addition of flaps on the new equipment. It was then necessary to qualify at least the minimum number of pilots required to operate the new ships. The average pilot involved had a background of at least 3000 hours in the old, though nearly similar fleet, yet the average period of training given these pilots to familiarize them with the new ships was double that which was necessary to teach him to fly originally. The cost of this training was, roughly, 10 percent of the cost of the equipment.

Stability

A stable airplane is, of course, always desirable to the pilot. The order of importance of stability to the pilot is probably longitudinal, lateral and directional.

Longitudinal stability is of the least importance in the normal cruising speeds. In this condition, complete stability is convenient but not particularly dangerous when lacking if the oscillations are of fairly small magnitude. The ship that becomes unstable in a dive, is, of course, dangerous, especially when accompanied by high control forces. At least one fatal accident to a commercial transport could be attributed to this particular characteristic.

The ship that becomes unstable longitudinally at low speeds is not only inconvenient but dangerous.

In an ordinary descent on instruments to a fairly low ceiling with poor visibility, a ship that is stable is a great aid to the pilot.

Most desirable is the ship that can be trimmed for near minimum speed and which, with reduced power, will "settle" in this attitude with a minimum of attention. The pilots may then give proper consideration to the many other perplexities of a safe descent under these conditions.

It is possible that the pilot might also be confronted with a situation in which his only means of knowing the longitudinal attitude of his ship is through "feel." This condition can easily arise when ice has accumulated on the airplane and the pilot is flying by instruments. Ice very often affects the accuracy of the airspeed indicator and even when this is not the case, the deposit of ice on the wings increases the stalling speed to an unknown quantity. This leaves only the artificial horizon to inform the pilot of his longitudinal attitude and this indication must be qualified if any turns have been recently made, as the horizon is materially affected by turns and requires several seconds to regain its correct attitude. From this, it is apparent that the pilot may find himself in a delicate situation following

an attempt to spiral up through an icing condition or to maneuver down through for a landing unless he has definite "feel," through positive control forces, of the approaching stall. Pre-stall buffeting is hardly enough to cope with this circumstance as the buffeting is usually at a minimum with power on and with ice on the propellers the natural roughness of the airplane reduces the evidence of the buffeting to a possible negligent amount.

Lateral stability is, of course, desirable, as a convenience as well as an aid in lateral control when used in conjunction with an effective rudder. In this manner, it is highly useful for getting a wing up when the ailerons are inadequate for the occasion.

Directional stability is most desirable when it reaches a point approaching a neutrally stable condition. Ordinarily, a ship which is marginal in directional stability at high angles of yaw is satisfactorily stable under normal flight conditions. Exaggerated directional stability only results in undue yawing in gusty cross-winds and deprives the pilot of the ability to sideslip the ship if the occasion arises.

Maneuverability

The amount of maneuverability desirable in large airplanes has been a subject of some debate. The pilot's opinion of this question can be expressed in a few words. With the growing popularity of the light plane and ever increasing number of amateur pilots flying, the possibility of collision in the air is increasing daily. It seems only fair to the pilot that every effort should be made to build into the airline ships maneuverability equal to that of the ships he is likely to have to outmaneuver. The other ship in this case is not another scheduled flight, but the itinerate pilot. It is comparatively easy to keep aware of the whereabouts of the other airliner, but literally impossible to do so in the case of the private flyer. It is not an infrequent occurrence for big ships to have to execute maneuvers violent enough to throw passengers from their seats in order to avoid hitting other ships. Aviation is the only mode of transportation in which the collision hazard has not decreased with increased size of the carrier and, unfortunately, considering the results of a collision, the collision hazard is increasing with the larger ships. Therefore, it can be seen that the pilot is justified in asking the greatest degree of maneuverability possible in a large ship. Naturally the necessity for this type of maneuverability is less in ships designed for trans-oceanic service where the exposure to collision is a minimum.

Wing Loading and Flaps

The question of high wing loading is one much discussed among pilots. Naturally the only concern of the pilot in this matter is airplane behavior, and all pilots appreciate the advantages of a heavily loaded wing at high speed. Consequently their greatest concern is the result at fairly low speeds, ice carrying characteristics, radius of turn while maneuvering for landing, etc., and the landing speed itself. Flaps of various types have increased the lift sufficiently to allow reasonably slow landings even with comparably high loadings. However, the commonly used flap while increasing the lift increases the drag to such an extent that it leaves the ship with practically zero reserve power even in the fairly low speeds. The result is an extremely steep angle of descent with power off. To justify the contention that the angle is much steeper than necessary it will be noticed that in service this maximum angle of descent is rarely ever used, the pilots ordinarily using only part flaps or approaching with considerable power.

Ice is probably the greatest cause for the pilots skepticism regarding highly loaded wings. In spite of the effectiveness of de-icers, even a moderately small deposit of ice over the ship increases the drag tremendously. In an airplane with light wing loading the pilot is able to retain some reasonable degree of performance in icing conditions by reducing speed which, of course, reduces the added drag of the ice. Contrary to this is the ship with a high wing loading and accompanying high minimum speed with flaps up. If the pilot attempts to increase lift in order to fly slower his only recourse is to lower the flaps which in turn increases to impossible limits the already high drag. In addition, it is necessary to consider the early stalling characteristics of a wing with an ice deposit due to the spoiler effect of the rough coating.

A low drag, lightly loaded airplane that "floats" in landing is undesirable. However, a typically clean modern transport with retractable gear, controllable propellers and maximum allowable landing speed, with gear extended, will have a gliding angle sufficiently steep to allow normal landings on any field from which safe take-offs may be made.

An airplane, typical of present airline equipment, in which only a fraction of its best climb is available with flaps extended is an added hazard at congested airports where quite frequently traffic brushes make it necessary for the pilot to "go-round" after his flaps are extended for landing. This often happens very near the ground and places the pilot in an awkward position since he cannot retract his flaps until he can accelerate sufficiently to offset the loss in lift when the flaps are raised and acceleration is extremely slow with the reduction in reserve power caused by the high drag flaps.

It seems to the author that, in the interest of safety and high wing loadings, more effort might be directed to the development of a flap and wing compromise that would retain the high lift qualities of our present conventional flap but without the high drag. The result would be an airplane with all the advantages of a high wing loading yet maneuverable and with the ice-carry-

ing ability of a lightly loaded wing. Perhaps there would be a slight increase in skill or effort required on the part of the pilot in attaining the proper glide in the normal landing but in the abnormal landing condition the skill required would be much less and the safety much greater regardless of skill.

Minimum Speed

Within the last ten years, the actual landing speed of large airplanes has not been materially increased, yet the safe minimum maneuverability speeds have been increased approximately 50 percent.

In arriving at an airport under a condition of given horizontal visibility, the time allowed the pilot to make decisions, execute maneuvers, perform the many mechanical chores necessary, radio contacts, etc., varies in inverse proportion to the minimum safe handling speed of the airplane. In the last ten years, the duties the pilot must perform to bring his ship down under adverse conditions have increased many fold, yet the time available for the execution of these duties has been materially decreased. In all other forms of transportation the time interval between the arrival at an obstruction and its first visual appearance can be kept fairly constant by the reduction in speed. In a heavily loaded airplane with a minimum safe maneuvering speed of say 120 m.p.h. attempting to land with visibility limited to one-eighth mile, the pilot is allowed less than four seconds from the time he first sees the obstruction until his decision must be made and his maneuver completed. From this, the extreme importance of low minimum handling speeds and absolute familiarity of the pilot with his equipment is apparent.

In discussing performance in airline equipment, it is needless to say that the greater the reserve power, the better the pilot's opinion of the ship. In fact, the author can see no justifiable reason why power loadings should not be much lower for take-off, climb, altitude, and emergency operations, and cruising limits reduced for reliability and economic reasons. As a result, operating costs per mile could be approximately the same, the initial cost only slightly higher, the payload possibly slightly less, and the safety in emergency greatly increased.

Power Available

The operating cost per mile is only important in its relation to revenue per mile and probably no other factor will increase revenue more surely than complete safety. The fuel costs of the average airline airplane will not exceed the revenue of one-tenth of the maximum payload.

The author feels that steps should be taken to improve the "one-engine inoperative" performance of airplanes, since schedules sometimes require taking off from an airport, the density altitude of which in the summer months is often higher than the claimed absolute ceiling of his ship with one-engine not operating.

While "pilot confusion" is undoubtedly responsible for far more accidents than "under power," "under power" has been either directly or indirectly the cause of some.

Landing Gear

The tricycle landing gear, with which most airline pilots have had little or no experience, presents problems as well as advantages.

Undoubtedly the directional ground stability inherent in an airplane equipped with the tricycle gear will be greatly appreciated by the pilot. To be able to use brakes without having to govern their use by varying center of gravity positions as well as the guarantee against nose-over and ground loop will help considerably.

Proper take-off technique is assured during the early part of the roll and, in all probability, the result of continued use of this landing gear will be longer level attitude rolls and, naturally, faster and safer take-off speeds. A repetition of at least one recently fatal take-off crash, in which a transport bounced off prematurely and the pilot attempted to continue on, will not be likely to occur. In this case, the airplane had to be held at such an extremely high angle of attack that level flight could not be maintained with the power available. There was not sufficient altitude to nose down to gain speed and, consequently, the ship finally settled to the ground with fatal results.

In some recent tests with a conventional bimotored transport, it was found that the distance required to accelerate from 70 to 105 m.p.h. on the ground in zero lift attitude, the entire weight of the craft being borne by the wheels, was 1400 feet whereas the distance required with the wings supporting the weight was 2300 feet—an increase of 64 percent. The difference in drag between high and zero angles is quite apparent from these results.

It follows that the braking problems in an airplane with a level attitude roll are perhaps doubled. This, of course, is largely the problem of the engineer and maintenance crews, but directly affects the pilot. Landing without braking may be necessary, either due to failure of the brakes or to the lack of friction. An airplane with conventional landing gear may be ground looped, to an angle at which the tires are sliding sideways or completely around to 180° at which time the motors may be opened to stop the backward slide. This is not an uncommon maneuver on slippery surfaces and considerable damage to equipment has been prevented by its use. This would obviously be impossible with a tricycle gear.

It is believed that on a tricycle gear there should be a steerable nose-wheel, so that, in the event of braking failure, the pilot could at least have a choice of what means will be used to stop without first having to extend

his roll, as for instance when an outboard motor is used for directional changes. It is, of course, assumed, that these fast, non-braking landings are made into "no wind" with little or no rudder control at the slower speeds. In addition it appears improbable that a ship can continually operate without at least a center locking nose-wheel and, if the engineer would design his structure for a locked nose-wheel, there would be very little more needed to make it steerable. It is felt that a center locking nose-wheel is necessary because it is sometimes necessary to land on a field with snow or mud deep enough to move the point of force application far enough ahead of the fork axis to eliminate all castering effect and possibly render the nose-wheel directionally unstable.

Controls

There has been considerable discussion lately of the advantages and disadvantages of non-reversible controls, especially regarding their installation on larger airplanes.

With extremely large control surfaces, particularly rudder and elevator, the abuse they receive in down-wind taxiing and parking might easily become critical. A non-reversible arrangement would obviously relieve both pilot and structure. There also seems to be a possibility of avoiding control surface flutter through the use of non-reversible arrangements. One multi-motored design, clean enough to permit rather high diving speeds, and having statically unbalanced ailerons has, by the use of a worm gear, accumulated over a half-million flying hours without a known case of aileron flutter. This worm gear is at the aileron and is actuated by a conventional cable arrangement. Although not completely irreversible, it is sufficiently so to act as a snubber and, in all probability, is responsible for the flutter-free history of these ailerons. This ship has never been troubled with aileron whipping by tail winds on the ground. However, it has had a number of rudders damaged due to this cause. Possibly a like arrangement could be incorporated in the rudder and elevator to reduce down-wind taxiing troubles as well as to reduce loads on the entire control system when the controls are secured in the cockpit for parking. A simple method of fastening the controls, in conjunction with this worm gear, or equivalent apparatus, seems somewhat more practical and dependable than some recently developed gust locks. At least some such protection to the control system against control flapping gives assurance to the pilot. It is the concensus of pilot opinion that one tragic accident the result of a transport "spinning in," was started originally by the ailerons whipping over, caused by aileron over-balance due to a deposit of ice on the leading edge of the aileron. Based on this assumption, it seems reasonable that had these "aileron-to-wheel" forces been snubbed, the pilot might have been able to handle the over-balance and thus prevent the beginning of the spin.

A night take-off under stormy conditions keeps a pilot quite busy without his having to worry about whether or not his controls were damaged by the wind before he got into the ship. There have been several cases in scheduled operations, in which pilots, after taking off, discovered that they had no rudder control.

The use of the automatic pilot as a control centering device for taxiing, and as a control lock for parking is becoming more or less a standard procedure in ships equipped with this accessory.

A snubber, such as the worm gear would obviously reduce loads in the control system during these conditions or would make it unnecessary to locate the automatic pilot servo cylinders at the surfaces, thereby simplifying the hydraulic system.

Complete irreversibility would be extremely objectionable to the pilot. The type just mentioned with the trouble-free ailerons, as originally delivered was equipped with such an aileron control. Naturally, in even slightly rough air, the pilot could not locate center or neutral. To correct this trouble a slight increase in the pitch of the worm gear allowed the ailerons enough of an advantage to make it possible for them to be self-centering. This procedure would also be sufficient on the other two surfaces.

Instrument Landings

Contrary to general belief, the new art of instrument landings will demand nothing new in the design of an airplane. Recently, exhaustive tests were completed in which thousands of instrument landings were made. From these tests, definite conclusions have been drawn as to the requisites. Any airplane, manageable enough to be accurately flown by instruments is suitable for this type of service. Features which might be considered desirable are as follows:

(1) Stability at low speeds, especially lateral stability which reduces by one third the flying effort of the pilot, and allows greater concentration on longitudinal and directional accuracy.

(2) A fairly light and especially effective rudder control, to make possible small skidding course corrections.

(3) Since it is not considered safe to fly at minimum speed near the ground on instruments, because from the present instruments one gets only indication and not anticipation, the normal instrument landing is made from twenty to thirty m.p.h. faster than a normal visual landing. Therefore, the correspondingly greater importance of a low minimum speed is apparent.

(4) The landing gear should be rugged enough to handle fairly high side-loads which occur when striking the ground while correcting for crosswind or during course corrections. Vertical loads in the landing gear

can be considered smaller for the average instrument landing than for the average visual landing.

In this connection, tests were conducted with ships of from 5000 to 25,000 lbs. gross weight, single to trimotor, monoplane and biplane with and without flaps, operated manually and with the automatic pilot, and with one engine inoperative in twin engined equipment. All results were quite satisfactory.

(5) As already stated, braking ability is important. The speed of landing is quite high and the point of contact with the ground averages from 2700 to 2900 feet from the far end of the runway at which point the landing path transmitter is located. The tricycle gear has advantages over some conventional landing gears inasmuch as brakes may be fully applied without the pilot having to be concerned with nose-over.

Ground handling characteristics are not particularly important. Directional stability such as is found in the tricycle landing gear reduces the duties of the pilot somewhat, but at the same time deprives him of the alternative of a ground loop. The characteristic of the tricycle gear is perhaps a greater help to the instrument take-off than to the instrument landing, because it reduces the required skill for a straight roll and encourages a faster take-off speed.

A brief description of the technique used in the recently accepted system of instrument landing is given below.

Before intersecting the glide path, the pilot prepares the ship for landing, extends the landing gear, adjusts the flaps to the desired position and the other customary duties which, on the average airplane are too numerous to mention. After this, the throttles are set to the minimum power necessary to maintain level flight at just above minimum speed. The glide path is intersected at 1500 feet, five miles from the boundary of the field. At this point the glide is fairly steep, gradually flattening out to a slope of about one-in-eighty at the point of contact. Consequently, with fixed power the glide is somewhat fast at the start, gradually slowing down to the predetermined minimum as the field is reached. The throttles are not touched until the wheels are on the ground; then they are closed and the brakes are applied. The average impact of the practice landing, with the pilot under the hood, will not exceed 2 g.

Conclusion

An attempt has been made in this discussion to present to the designers of the airline airplane, the thought that there might be some slight increase in safety if the problems of the men who are directly responsible for this safety were a little better understood.

The pilots have unqualified respect and admiration for the engineers with the vision and ingenuity which has been used in the development of the highly efficient present-day transport. They have conscientiously tried to improve their knowledge and ability to the end that the greatest operating efficiency could be derived from the equipment. However, the time is rapidly approaching when the "least capable" pilot will have reached the saturation point and a halt in the ever increasing "pilot skill required" will be necessary.

New Developments in Seamless Steel Tubing

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Presented at the Structures Session, Sixth Annual Meeting, I. Ae. S.
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SUMMARY

The use of welded tubular construction in aircraft has brought about the replacement of plain carbon steel by the present almost universal use of chromium molybdenum (S.A.E. X4130) steel tubing. It is the purpose of this research to investigate the properties of tubing made from other alloys, in particular chromium-nickel-molybdenum steel, with a view to finding something with more advantageous properties than the material now employed.

The tensile properties of two sizes of S.A.E. 4340 tube have been determined and the effect of welds has been investigated by strut compression tests. A comparison has been made between the strength of plain tube sections and those possessing straight and V welds and the effect of a right angle connection has been determined through tests on T-shaped specimens.

THE importance of weight reduction in aircraft construction has been responsible for the development of many light weight and high strength alloys which have directly or indirectly permitted saving in weight. Improvements in construction have played their part toward cutting down on weights but equally important are the improvements in materials of construction which have permitted saving in weight through the carrying of higher stresses in smaller sized members.

The tubular type of construction of airplane parts has been developed by improved welding, fabrication, and by improvements in the tubing used. A tube suitable for aircraft work should be smooth, easy to weld, obtainable in uniform sizes and should be made of high strength material capable of withstanding the action of repeated stress. For large structures the material should be capable of retaining its high physical properties without heat treatment subsequent to welding, but for the smaller frames, such as engine mounts, which can be heat treated as a whole after fabrication, this is unimportant.

The question as to whether one tube is better than another or whether one material has advantages over another can only be determined by those engaged in the industry using the particular materials or tubes after all available data concerning the various properties have been collected and carefully studied.

MATERIAL

The data given in the following paragraphs were obtained from circular cold-drawn, seamless, chromium-nickel-molybdenum steel tubing (designated as S.A.E. 4340) supplied through the courtesy of the Summerill Tubing Company, who suggested carrying out the investigation. In order to duplicate the conditions in an airplane factory the welded specimens were made up by the Kellett Autogiro Corporation of Philadelphia. The chemical composition of the steel, as given by the manufacturer, was as follows:

C	0.36	Cr	0.74
Mn	0.65	Ni	1.97
P	0.012	Mo	0.39
S	0.012		

The manufacturer also supplied the following data with regard to the heat treatment of the material: "After fabrication all this material was annealed in closed chromium steel retorts at 1300°F. for $1^1/_2$ hours. The welded sections were reannealed after welding at 1300°F. for one hour. All specimens were then heated to 1525°F. for $^1/_2$ hour and quenched in oil. They were then tempered at 625°–640°F. for $^3/_4$ of an hour."

TENSILE TESTS

The data given in Table 1 were obtained from tensile tests on eight specimens, four of $1^3/_4$ in. O.D. × .048 in. wall thickness and four of $1^3/_4$ in. O.D. × .067 in. wall thickness (nominal sizes).

Micrometers were used for measuring both the outside diameter and the wall thickness; for the former, four observations (two perpendicular diameters near each end), and for the latter, eight observations (four near each end) were made. The average outside diameter and wall thickness of each tube were used to calculate the cross-sectional area.

Elongations up to the yield point were measured with a pair (one on each side of the specimen) of Huggenberger tensometers of 1 in. gage length and the average of the strains of the two sides of the specimen was determined. Each specimen was marked off every inch between the jaws of the testing machine and the elongations beyond the yield point were measured to the nearest .01 in. in a distance of 5 in. Ultimate elongation was measured in the 2 in. containing the fracture.

Figs. 1 and 2 show the average stress-strain relationships for the two sizes of tube tested. The same data are plotted on two scales of abscissa in order to indicate the proportional limit clearly.

TABLE 1

Tensile Properties

Specimen No.	Average O.D. (In.)	Average Thickness (In.)	Tensile Strength (Lbs. per Sq.In.)	Westinghouse Yield Point* (Lbs. per Sq.In.)	Proportional Limit (Lbs. per Sq.In.)	Modulus of Elasticity (Lbs. per Sq.In.)	Elongation (Percent of 2")
			Nominal size: 1 3/4 in. O.D. × .048 in. wall thickness				
1	1.753	.053	220,000	197,000	126,000	28.7×10^6	7
2	1.755	.053	225,000	202,000	134,000	29.3×10^6	7 1/2
3	1.755	.053	216,000	196,000	126,000	28.5×10^6	6
4	1.755	.052	217,000	196,000	144,000	28.6×10^6	7 1/2
Average	...	...	220,000	198,000	133,000	28.8×10^6	7
			Nominal size: 1 3/4 in. O.D. × .067 in. wall thickness				
5	1.752	.067	232,000	217,500	169,000	29.2×10^6	6 1/2
6	1.754	.068	227,000	206,000	167,000	29.1×10^6	5
7	1.754	.068	225,500	204,000	160,000	29.8×10^6	7
8	1.753	.068	228,000	205,000	160,000	29.4×10^6	8 1/2
Average	...	...	228,000	208,000	164,000	29.4×10^6	6 3/4

* Westinghouse Yield Point indicates the stress intensity at which the permanent set = 0.2 percent of the gage length.

TABLE 2

Compression Strength

Specimen No.	Average O.D. (In.)	Average Wall Thickness (In.)	Length (In.)	Comp. Strength (Lbs. per Sq.In.)	Mode of Failure
		Nominal size of all specimens: 1 3/4 in. O.D. × .067 in. wall thickness			
			Straight Butt Weld		
1	1.755	.067	7 1/8	226,000	Buckled at weld
2	1.754	.067	7 1/8	220,000	Buckled at weld
3	1.755	.065	7 1/8	230,000	Buckled at weld
			Average	225,000	
			V Type Weld		
4	1.755	.068	7 1/8	214,000	Buckled at weld
5	1.755	.068	7 1/8	204,000	Buckled at weld
6	1.755	.067	7 1/8	211,000	Buckled at end
			Average	210,000	
			Plain Tube		
7	1.754	.067	7 1/8	226,000	Buckled at end
8	1.754	.0665	7 1/8	232,000	Buckled at end
9	1.754	.066	7 1/8	231,000	Buckled at end
			Average	230,000	

COMPRESSION TESTS

Table 2 shows the results of three sets of compression tests performed on specimens containing straight butt welds, V type welds, and the plain unwelded tube.

The ends of all compression specimens were ground off plane and perpendicular to the axes of the tubes. All tests were conducted with one end of the tube on a ground steel plate and the other end on the flat (ground) surface of a 2 in. diameter hemisphere held in a well greased socket. Correct alignment was obtained by adjusting the hemisphere so that its center lay on the axis of the tube. This arrangement with the center of the ball joint in the plane of the end of the tube and at the center of gravity of the cross

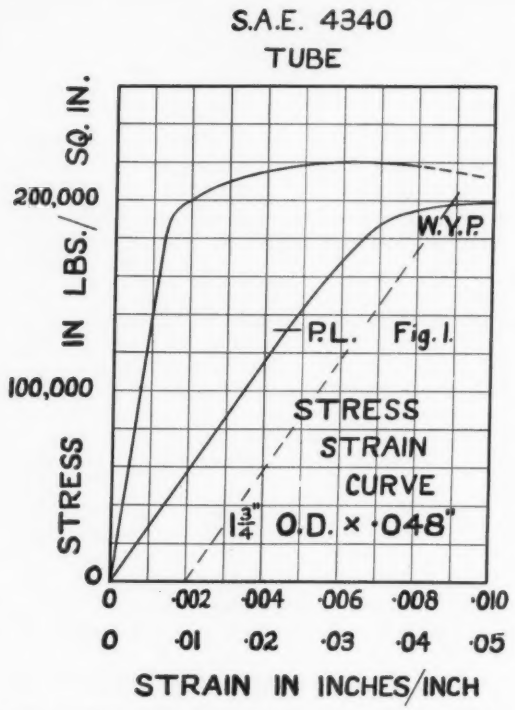

FIG. 1. Stress-strain curve (1¾ in. O.D. × .048 in. tube).

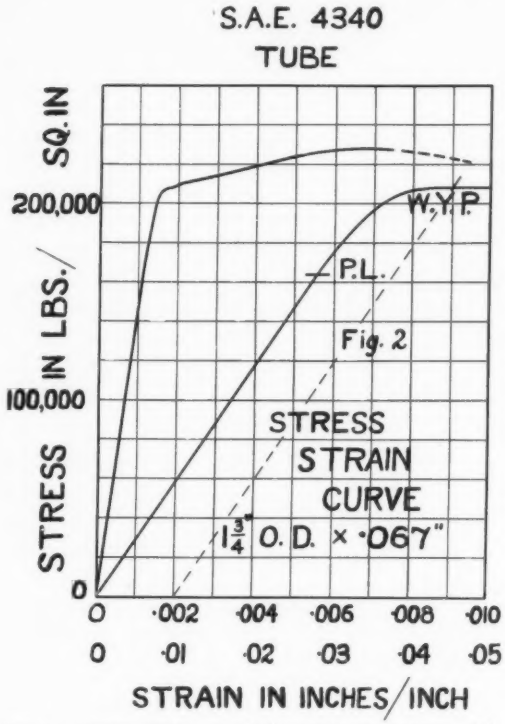

FIG. 2. Stress-strain curve (1¾ in. O.D. × .067 in. tube).

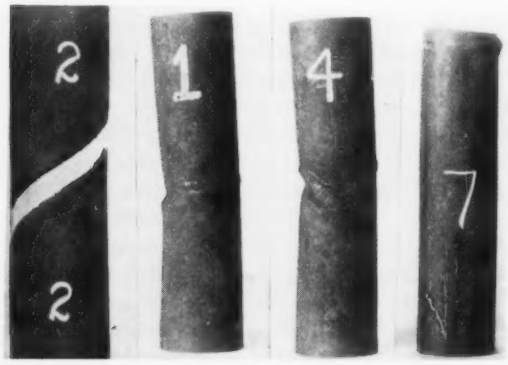

FIG. 3. Typical tension and compression failures.

section provided a suitable and convenient means of applying the load to the specimen.

Measurement of the cross-section of the compression specimens was made in the same manner as employed for the tensile tests.

Fig. 3 shows typical failures obtained in the tensile and compression tests. From the data it appears that the presence of the welds in the compression specimens has only a very slight effect in reducing the strength of the tube. It will be recalled, of course, that the welded specimens were re-annealed and heat treated after welding.

To determine the effect of welding two tubes together at right angles, 4 T-shaped specimens 1¾ in. O.D. × .067 in. wall thickness were tested. Two of these were tested with the cross member rigidly supported as shown in the jig (Fig. 4). The load was applied through a ball joint to the vertical leg and it was found that the weld sustained the loads satisfactorily but that the flattening effect on the cross member caused the latter to split immediately below the vertical leg; this failure is shown in Fig. 4. As this arrangement of the rigid support was merely to find out whether the vertical leg would be driven through the cross member, it was decided to test the other two specimens with the cross members freely supported on spans of 12 in. and 8 in., respectively. The former shows a failure due to buckling of the tube where the bending is a maximum; for pure bending this type of failure is to be expected. The other specimen shows the very interesting condition of a simultaneous failure by bending and splitting of the tube. The two types of failure are illustrated in Figs. 5 and 6, respectively (see also Table 3).

A question may be raised in connection with the maximum loads obtained on specimens B and D under conditions of rigid support. These two tests give close agreement with each other but show a lower maximum strength than that obtained with the 8 in. span of specimen C. At first this appears unusual since one would naturally expect a reduction in maximum load as the span increased; however, on examination of the method of failure it appears that in the case of rigid support the cross tube fails by crushing and not as a beam. A freely supported span relieves

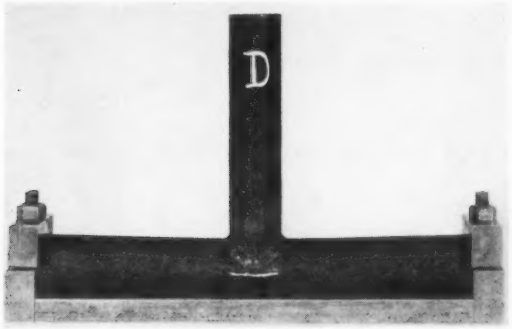

FIG. 4. Jig for testing and failure of rigidly supported T-shaped specimen.

FIG. 5. Failure of T-shaped specimen freely supported on a 12 in. span.

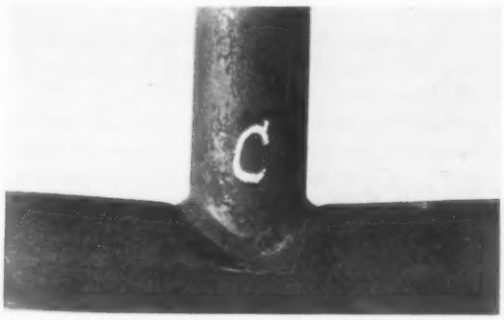

FIG. 6. Failure of T-shaped specimen freely supported on an 8 in. span.

TABLE 3

T Sections

Specimen	Support	Maximum Load (Lbs.) (Applied to Vertical Leg)	Type of Failure
A	12 in. span free supports	15,000	Bending of cross tube
B	Rigid support	19,500	Splitting of cross tube
C	8 in. span free supports	23,100	Bending and splitting of cross tube
D	Rigid support	19,100	Splitting of cross tube

this condition of crushing and one may therefore expect a higher load to be carried until the span is increased to such a length that the stress on the top of the horizontal tube has reached the compressive strength of the material.

In passing, it is interesting to note that the maximum apparent stresses at the edges of the welds (on the top of the cross tube) in specimens A and C are 262,000 lbs. per sq.in. and 242,000 lbs. per sq.in., respectively. If allowance is made for the difference in span length and load carried by the vertical member, these figures agree very well, and in addition they agree with the values found for the compressive strength of the material. As one would expect with a modulus of rupture, these results are slightly higher than the compressive strength.

The foregoing information, presented with the idea that it may be useful to industry, is the result of the preliminary investigation into the properties of chromium-nickel-molybdenum tube. It does not lie with the author to make any comment on the merits of the material other than to state that the data given here agree with the work done in other laboratories on bar stock. Considerable interest has been shown in regard to the possible applications of this tube and plans have already been laid for continuing the investigation to cover other kinds of tests and different sizes and shapes of tubes.

Stress Distribution in Reinforced Panels

TUNG-HUA LIN, *Tsing Hua University, China*

(Received July 18, 1938)

THE problem of "shear-lag" in the design of all-metal semi-monocoque wings has been investigated by R. J. White and H. M. Antz.[1] As presented there, the constants η and A_T would have to be determined from test data and hence would involve considerable difficulty in applying the equation to practical cases. The empirical value of η of 0.1175, as calculated from the White and Antz data, shows quite a deviation from the theoretical curve.

The following analysis gives a rational method of calculation, which does not involve the use of constants obtained from test data on the particular panel to be designed. This gives a clearer comparison between the theoretical and test results.

The lower value of η obtained by White and Antz is mainly due to the neglect of the effective width of sheet which is appreciable as compared to the small area of the stiffener.

The change in modulus of rigidity after buckling is considerable. So instead of using an empirical factor calculated from the particular test, equations including the effect of the change during buckling are derived by the author in the following analysis.

The following symbols are used:

G = Shear rigidity
G' = Modified shear rigidity for tension field = $^1/_4E$
E = Modulus of elasticity
τ = Shearing stress
γ = Shearing strain
t = Thickness of the sheet
t_z = Distance between two stiffeners
A_1 = Effective area of side stiffener
A_2 = $^1/_2$ Effective area of center stiffener
P_1 = Total load in side stiffener
P_2 = $^1/_2$ Total load in center stiffener
L = Total length of the panel
S = Total shear transferred from the side stiffener to the center one
u = Relative displacement of the two stiffeners. At $x = 0$, $u = u_0$.

Judging from the tests by different observers, after buckling, the sheet still carries the buckling shear stress in shear and only the surplus shear $(\tau - \tau_0)$ in diagonal tension.

Referring to Fig. 1 the loads in the side and center stiffeners are given by

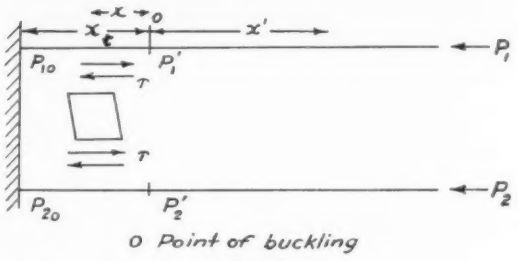

FIG. 1.

$$P_1 = P_{1_0} + \int Gt\gamma\, dx;\quad P_2 = P_{2_0} - \int Gt\gamma\, dx$$

the corresponding displacements of the stiffeners are

$$u_1 = \int \frac{P_{1_0} + \int Gt\gamma\, dx}{EA_1}\, dx;\quad u_2 = \int \frac{P_{2_0} - \int G\gamma t\, dx}{EA_2}\, dx$$

where u_1, u_2, and γ obey the following relations:

$$u = u_1 - u_2;\quad \gamma = u/tx$$

Whence,

$$u = \int \frac{P_{1_0} + G\gamma t\, dx}{EA_1}\, dx - \int \frac{P_{2_0} - \int G\gamma t\, dx}{EA_2}\, dx$$

The differential displacements in stiffeners 1 and 2 obey the following equation:

$$\frac{d^2u}{dx^2} = \frac{G\gamma_0 t}{EA_1} + \frac{G\gamma t}{EA_2} \qquad (1)$$

$= (1/E) \times$ (Change of the differential stress in stiffeners 1 and 2)

Introducing G_1, the modified shear rigidity,

$$\frac{d^2u}{dx^2} = \frac{G\gamma_0 t}{EA_1} + \frac{G\gamma_0 t}{EA_2} + \frac{G'(\gamma - \gamma_0)t}{EA_1} + \frac{G'(\gamma - \gamma_0)t}{EA_2}$$

$$= \frac{\gamma_0 t}{E}\left(\frac{1}{A_1} + \frac{1}{A_2}\right)(G - G') + \frac{G'ut}{Et_z}\left(\frac{1}{A_1} + \frac{1}{A_2}\right)$$

The solution of this differential equation can be put in the form,

$$u = A \sinh K'x' + B \cosh K'x' - C/K'^2 \qquad (2)$$

where

$$K'^2 = \frac{G't}{Et_z}\left(\frac{1}{A_1} + \frac{1}{A_2}\right)$$

$$C = \frac{\gamma t}{E}\left(\frac{1}{A_1} + \frac{1}{A_2}\right)(G - G')$$

and A and B must be determined by the boundary conditions:

$$\text{at } x' = 0,\ u = u_0,\ \tau = \tau_0,\ du/dx = (P_1'/EA_1) - (P_2'/EA_2)$$

Using these boundary conditions,

$$A = \frac{1}{K'E}\left(\frac{P_1'}{A_1} - \frac{P_2'}{A_2}\right)$$

$$B = u_0 + (C/K'^2)$$

and

$$u = \frac{1}{K'E}\left(\frac{P_1'}{A_1} - \frac{P_2'}{A_2}\right)\sinh K'x' + \left[u_0 + \frac{\gamma_0 t}{K'^2 E}\left(\frac{1}{A_1} + \frac{1}{A_2}\right)(G - G')\right]\cosh K'x' - \frac{\gamma_0 t}{K'^2 E}\left(\frac{1}{A_1} + \frac{1}{A_2}\right)(G - G') \quad (3)$$

The total shear transferred from the side to the center stiffener is found as follows:

$$dS = \tau t\, dx$$

where $\tau = G\gamma_0 + [G'(u - u_0)/t_x]$

$$S\Big|_{x'=0}^{x'} = \int_0^{x'} \tau t\, dx$$

$$= G\gamma_0 t x' - G'\gamma_0 t x' + (G't/t_x)\int^{x'} u\, dx$$

$$= \gamma_0(G - G')t x' + \frac{G't}{t_x}\left[\frac{1}{K'^2E}\left(\frac{P_1'}{A_1} - \frac{P_2'}{A_2}\right)(\cosh K'x' - 1)\right] + \frac{G't}{K't_x}\left[u_0 + \frac{\gamma_0 t}{K'^2E}\left(\frac{1}{A_1} + \frac{1}{A_2}\right)(G - G')\right]\sinh K'x' - \frac{G't}{t_x}\left[\frac{\gamma_0 t}{K'^2E}\left(\frac{1}{A_1} + \frac{1}{A_2}\right)(G - G')x'\right]$$

$$= \frac{G't}{t_x}\left[\frac{1}{K'^2E}\left(\frac{P_1'}{A_1} - \frac{P_2'}{A_2}\right)(\cosh K'x' - 1)\right] + \gamma_0 t G\frac{\sinh K'x'}{K'}$$

$$= \frac{(P_1'/A_1) - (P_2'/A_2)}{(1/A_1) + (1/A_2)}(\cosh K'x' - 1) + \tau_0 t\left(\frac{\sinh K'x'}{K'}\right) \quad (4)$$

Based on the above equations, the stress curves of the stiffened panel tested by White and Antz are calculated with the test data as follows:

$\tau_0 = 4.4\,\dfrac{E}{1-u^2}\,\dfrac{t^2}{d^2}$ (See reference 2.)

$\tau_0 = 845$ lbs. per sq.in., $\quad \tau_0 t = 21.1$ lbs. per in.

$\gamma_0 = 845/3{,}840{,}000 = 0.00022$ and

$u_0 = \gamma_0 t_x = 0.00132$

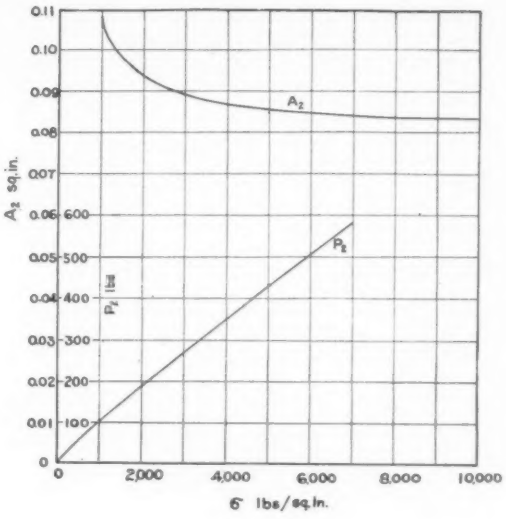

FIG. 2.

TABLE 1

σ_s	λ	w_e/b	$w_e t$	A_2	P_2	A_1	P_1
1000	.414	.43	.0645	.1085	108.5		
2000	.293	.33	.0494	.0934	186.8		
3000	.239	.30	.0450	.0890	267.0		
4000	.207	.29	.0434	.0874	349.6		
5000	.185	.280	.0420	.0860	430.0		
6000	.169	.270	.0404	.0844	506.4		
7000	.1566	.267	.0400	.0840		.220	1540
8000	.147	.267	.0400	.0840		.220	1760
9000	.138	.266	.0398	.0838		.220	1980
10000	.131	.264	.0396	.0836		.220	2200

Referring to the unbuckled sheet, Eq. (3) becomes

$$u = u_0 \cosh Kx + \frac{1}{K}\left(\frac{P_1}{EA_1} - \frac{P_2}{EA_2}\right)\sinh Kx \quad (5)$$

where $K = \dfrac{Gt}{Et_x}\left(\dfrac{1}{A_1} + \dfrac{1}{A_2}\right)$

The effective area of the stiffened sheet is calculated by means of Sechler's formula,[3] $\lambda = \sqrt{E/\sigma_s}\ t/b$ where σ_s is the yield point. For the White and Antz tests (specimen No. 1), $t = 0.025$ in., $b = 6$ in., and, using $E = 10^7$, $\lambda = 13.1/\sqrt{\sigma_s}$. Table 1 gives data referring to the unbuckled sheet. w_e/b, where w_e is the effective width and b is the actual width of the panel, is taken from Fig. 3 of Sechler's paper.

From these data values of $A_1 = 0.220$ and $A_2 = 0.084$ are taken. These values and the White and Antz data above give a value for $K = 0.163$. Values of A_2 and P_2 are plotted in Fig. 2.

The plate is assumed to buckle at 78.4 percent of its length (48 in.) giving a value of $x_t = 37.6$ in.

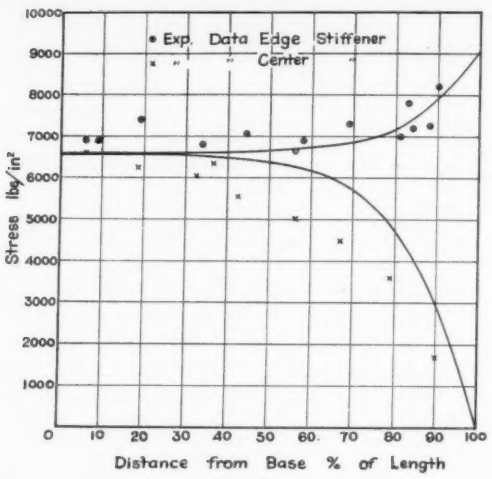

FIG. 3.

TABLE 2

x/L	x	$130.7 \times (1 - e^{-Kx})$	P_2	P_2/A_2	P_1	P_1/A_1
.084	4.03	63.0	485.0	5720	1515	6885
.184	8.84	99.6	521.6	6200	1478	6710
.284	13.64	116.6	538.6	6410	1461	6650
.384	18.42	124.2	546.2	6510	1454	6615
.584	28.0	129.3	551.3	6560	1449	6590
.784	37.6	130.2	552.3	6570	1448	6580

At the fixed end, $u = 0$. Substituting this and the value u_0 from above in Eq. (5) gives

$$(P_1/A_1) - (P_2/A_2) = 2150$$

which can be solved for P_1 and P_2, using A_1 and A_2 as given above and the relation $P_1 + P_2 = 2000$ (White and Antz tests). The result is

$$P_1 = 1578,\ P_2 = 422$$

For the unbuckled portion,

$$S = \frac{(P_1/A_1) - (P_2/A_2)}{(1/A_1) + (1/A_2)} \times [\tanh Kx_i \sinh Kx - \cosh Kx + 1]$$

which, taking $\tanh Kx_i = 1$, and making use of the exponential form of the hyperbolic functions, gives

$$S = 130.7\,(1 - e^{-Kx})$$

Table 2 gives data for the unbuckled portion of the plate.

After buckling the stress transferred from the end to the center stiffener is, from above, $P_2 = S = 422$. From Table 1, A_2 varies from 0.086 to 0.1085 and the weighted mean is 0.096. Using this value and $A_1 = 0.22$, $K' = 0.1245$.

Accordingly, substituting the numerical data available, Eq. (4) becomes

$$S = 144(\cosh K'x' - 1) + 21.1 \sinh(K'x')/K' \quad (4a)$$

TABLE 3

x'	$K'x'$	S	P_2	P_1	P_2/A_2	P_1/A_1
10.37	1.290	422.4	0	2000.	0	9100
7.	0.872	225.8	196.2	1803.8	2120	8200
4.	0.498	104.2	317.8	1682.2	3630	7650

TABLE 4

Dist. from Fixed End Percent of Total	P_2/A_2	P_1/A_1
0	6570	6580
10		
20	6560	6590
30		
40	6510	6615
50	6410	6650
60	6200	6710
70	5720	6885
78.4	4950	7100
86.74	3630	7650
93.0	2120	8200
100	0	9100

The values of P_2/A_2 and P_1/A_1 for the buckled portion of the plate, calculated by means of Eq. (4a) are given in Table 3. For the values in this table $P_2 = 422 - S$, and $P_1 = 2000 - P_2$.

The data from Tables 2 and 3 for the unbuckled and buckled portions of the plate, respectively, are combined in Table 4.

These data, plotted as curves in Fig. 3, show satisfactory agreement with the experimental data of White and Antz, shown in the same figure.

In the calculation, the angle of buckling is assumed to be 45°, but actually, due to the fact that the skin also takes some compressive stress along the wing axis and the line of wrinkle is perpendicular to the direction of maximum compressive stress, the angle of buckling is less than 45°, which will give smaller values of the modified modulus of rigidity, G', and will show better agreement with the test results. The author hopes that more tests will be carried out along this line and this calculation may be used for porportioning the most economical structures.

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Icing of Aircraft Antenna Wires

GEORGE L. HALLER, *Wright Field*

(Received October 18, 1938)

Summary

This paper describes experiments on the icing of aircraft antenna wires with emphasis on the relation of the icing, both form and weight, to the angle which the wire makes with the wind stream. A refrigerated wind tunnel providing a wind velocity of 80 m.p.h. was used. A critical angle region was discovered over which region the weight of the ice formation increases very rapidly. The diameter of the ice formation increases uniformly with the angle.

Introduction

USUALLY in the design of an aircraft antenna little consideration is given to the problem of icing, yet ice may form to such an extent that the antenna will be carried away and render radio communication impossible just when it is most needed. Antenna masts usually derive some support from the antenna wire and the release of this support in the breaking of the wire may allow serious vibration of the mast and its support. In some types of aircraft a definite strength limit must be placed on the wire so that the wire will not hinder or injure a man who is jumping from the airplane, although even if this restriction were removed it would still be impractical to build the wire strong enough to support the icing load which may be encountered. In a previous paper[1] an icing of 5 inches diameter on a radio antenna was reported and, while this antenna was not mounted on an airplane, it was subject to weather conditions which were similar to those encountered by aircraft antennas.

It has generally been observed and is to be expected that wires which are longitudinal with respect to the airflow collect less ice and carry away less often than transverse wires. Due to the possibility of rigging antenna wires at various angles to the wind stream and also due to the fact that most antennas consist of combinations of wires at different angles, a study was undertaken to determine the effect of the angle of the wire on the accumulation of ice.

Experimental Procedure

The refrigerated wind tunnel at the B. F. Goodrich Company[2] was used, in which a wind velocity of 80 m.p.h. could be obtained. The ambient temperature was 8°F. at the start of each run and rose to about 20°F. at the end of a two-minute run. Water was injected into the air stream at a temperature of 40°F. A compressed air mixing jet was used which produced a fine mist. The atmosphere was in an icing condition by the time it reached the throat of the tunnel. Several wires were mounted in the throat of the tunnel at different angles to the wind stream. At the end of each run a typical section of ice formation was selected on each wire and the diameter measured. Since the ice formation was not exactly circular, the "major diameter" was used. The ice was then collected and melted to determine the volume and weight per unit length. Solid wires No. 18 B. & S. and stranded wires 7 strands No. 25 B. & S. were used but the test curves cover only the stranded wire.

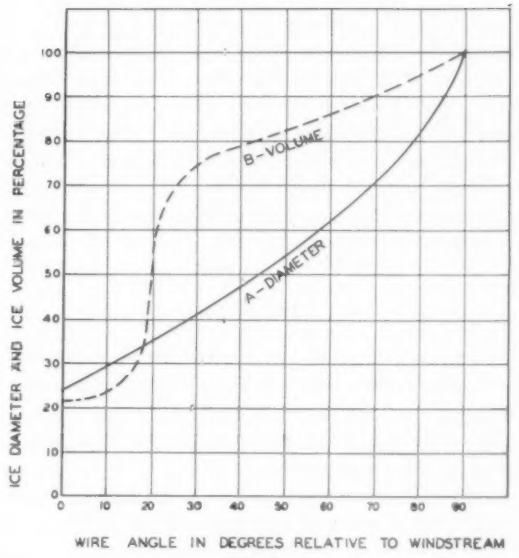

Fig. 1.

Results

Fig. 1 consists of two curves showing the percentage of ice diameter and ice volume per unit length of wire plotted against the angle which the wire makes with the wind stream. The ice diameter and ice volume percentage is relative to that diameter and that volume obtained when the wire is at 90° to the wind stream, which, in the experimental run of two minutes amounted to a major diameter of 0.86 cm. and a volume of 0.44 cu.cm. per cm. of wire length. Curve A shows that the diameter of the ice formation increases continuously with increasing projected area into the windflow.

The volume of the ice formation, curve B, Fig. 1, however, builds up slowly with the angle to a region between 15° and 25° over which region the volume

builds up very rapidly. The slope of the curve then decreases and is about uniform to 90°.

The photograph, Fig. 2, shows icing obtained on wires placed at various angles to the wind flow. The ice on the wires at angles below the critical angle region, *i.e.*, below 15°, is built up of small projections leaning toward the source of the wind. These small projections shadow a portion of the wire directly behind them, effectively preventing the formation of solid ice. This type of icing is shown on wires placed at angles of 0° and 12°. The wires at angles greater than the critical angle region show the formation of solid ice. In the photograph, Fig. 2, this is shown on wires placed at angles of 33° and 90°. As the angle of the wire is increased a point is reached where the shadow effect disappears and solid ice forms. The ice which forms on the wires at smaller angles is very fragile and could easily be broken off with any whipping of the wire in the wind.

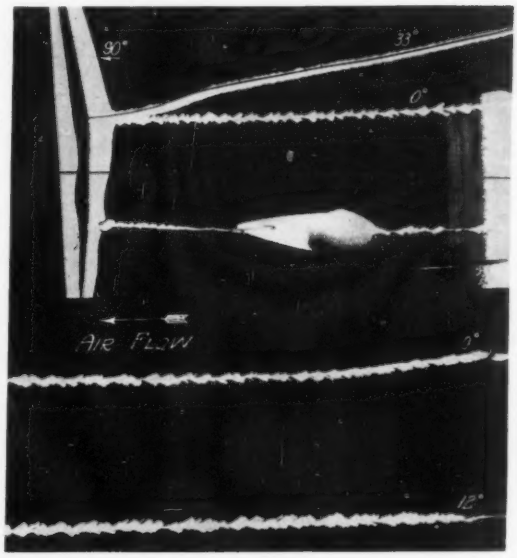

FIG. 2.

CONCLUSIONS

More data under conditions of higher wind velocity are needed before definite conclusions can be made regarding a critical icing angle, but due to the limitations of the test equipment these conditions cannot be obtained at the present time.

In general, the results indicate that antenna wires on aircraft should be installed with angles from the wind stream of less than 15° to 20° in order that the ice load be reduced and the ice formation will be as unstable as possible.

The author wishes to thank the B. F. Goodrich Company and the American Airlines for their cooperation in the performance of the experimental work.

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Letters to the Editor

September 19, 1938

Dear Sir:

Since the publication of my article entitled "An Alignment Chart for the Allowable Stresses for Spruce Beams in Bending and Compression" in the October, 1937, issue of the Journal (Vol. 4, No. 12, page 502), Niles and Newell in their second edition of "Airplane Structures," Vol. 2, page 89 make the following comment concerning the use of my alignment chart: "It represents conditions on the straight-line portion of the allowable stress curve, DE' of Fig. 14-6 [also shown in Aeronautics Bulletin No. 26, Fig. 18 and in ANC-5, 'Strength of Aircraft Elements,' Fig. 2-2], but leads to erroneous results when f_b/f_t is low enough to cause the allowable stress to lie on the part of the curve represented by the appropriate L/ρ line." That is, when the point F determined by f_b/f_t is below point E, the allowable stress is obtained from the L/ρ curve instead of the line DE'.

In order to take care of this case in using the alignment chart it is necessary to use the lower value of allowable stress indicated by the alignment chart or from the formula:

$$A = F_e/(1 - f_b/f_t)$$

where F_e = Euler's or Johnson's allowable stress for spruce columns whose value may be obtained from ANC–5, Fig. 2-1 or from the formulas (Eq. 2:1 and 2:2):

$$F_c = 13{,}000{,}000\,(L/\rho)^2 \text{ for } L/\rho > 72$$

$$F_c = 5000 - 0.50\,(L/\rho)^2 \text{ for } L/\rho < 72$$

Using this lower value as indicated will give the proper value of the allowable stress for spruce beams under bending and compression. However, the same precautions in the use of the nomogram as given in ANC-5 (pages 2–4) must be observed in the use of the alignment chart.

R. M. Carlson
University of Minnesota

November 1, 1938

Dear Sir:

Referring to Dr. von Kármán and Sears' Letter to the Editor in the October issue of the Journal, it seems preferable to reserve the further discussion of the scientific question involved for a separate paper. In the meantime, I dissent from the statements that the theorem is an "assumption" and that it is in any way incorrect.

Max M. Munk
Washington, D. C.

September 22, 1938

Dear Sir:

By this time you have undoubtedly received many letters as a result of Lieut. Hatcher's letter of May 23, which appeared in the July issue of the Journal. In case the question raised by Lieut. Hatcher has not yet been cleared up, I should like to point out that he has done structural engineers a great service by showing that the problem of shear stress distribution in a box beam is *not* a statically indeterminate problem, at least under the assumptions usually accepted. For years we have apparently been making the problem more difficult than it should be by assuming that we needed to know a "shear center" in order to calculate the shear stress distribution. This center has usually been defined as "the line of application of an external force F which produces no rotation of the cross-sections in their planes," (to use Hatcher's words). Such a shear center is needed only when we actually are interested in torsional rotation as such. The determination of this center is a statically indeterminate problem which has *not* been solved by Hatcher's simplified "stress centroid" system.

This new system is obviously the desired answer to the stress analyst's problem, especially when combined with the useful graphical method of determining the torsional moment of a shear flow which was described by Sibert in the February, 1938 issue of the Journal. It can even be modified to include allowance for "shear lag," if the designer wishes to make some assumptions as to the relative effectiveness of each member carrying axial load.

Perhaps a simple analogy would clarify the question as to whether a box beam is indeterminate as to shear distribution. If a horizontal bar is supported by a wire at each end, it is easy to calculate the wire loads caused by applying a pull at any point on the cross-bar. This problem is statically determinate. But if we wish to find the point to apply the pull such that the bar *will not rotate* from its horizontal position, we must consider the relative deflections of the two wires, involving their cross-sectional areas. This is obviously a statically indeterminate problem. (The term "statically indeterminate" is used here to indicate that the desired solution cannot be obtained solely from the equations of equilibrium; in other words, the elastic properties of the structure must be considered.)

In the case of a box beam or D-tube we can similarly determine the shear stress distribution by a statical method such as proposed by Hatcher. (This can be done for *any* assumed or calculated distribution of axial stresses.) But we still do not know the point of load application which will cause zero rotation. To find it involves deflections or least work, or it may be done by a "cut-and-try" method based on Hatcher's solution.

It appears, therefore, that the "paradox" referred to by Hatcher does not exist: he has simply solved a statically determinate problem by statics and the indeterminate problem of finding the shear center remains indeterminate.

In my opinion the Journal has rendered a valuable service to structural engineers by publishing the series of articles and letters on this subject. An exchange of ideas in this manner is bound to do a great deal of good and I hope the Journal will continue to serve as a medium for such exchange.

F. R. Shanley
Consolidated Aircraft Corporation

Institute Notes

Honors Night

On December 17, 1938, the Institute will again sponsor a celebration on the date of the thirty-fifth anniversary of the first flight of the Wright Brothers at Kitty Hawk.

The Wright Brothers' Lecture will be given by Hugh L. Dryden, Chief of the Mechanics and Sound Division of the National Bureau of Standards, at Columbia University at 3 p.m. The subject of the lecture will be "Turbulence and the Boundary Layer."

In the evening the Daniel Guggenheim Medal will be presented to A. H. R. Fedden, President of the Royal Aeronautical Society, "for contributions to the development of aircraft engine design and for the specific design of the sleeve valve aircraft engine." The medal will be presented by Mr. C. W. Spicer, President of the Society of Automotive Engineers. The sponsorship of this medal is shared by the S.A.E., the A.S.M.E., and the Institute, and the presentation will be under the joint auspices of the three societies.

Announcement will be made at the meeting of the election of Honorary Fellows and Fellows of the Institute for the year 1938.

The Sylvanus Albert Reed Award, the Lawrence Sperry Award, and the Octave Chanute Award will also be presented.

Before the meeting the Council will give a dinner at the Biltmore Hotel in honor of Mr. Fedden and Mr. Dryden, after which the Honors Night Meeting will be held in the Grand Ball Room. A collation will be served to guests and members.

Student Branches

University of Michigan. The first meeting of the school year was held on October 6. The following men were elected to fill vacancies: Vice-Chairman, Robert K. Tiedeman; Treasurer, Joseph I. Robinson; Secretary, Walter E. Hobert. M. J. Thompson gave a short talk on the history of the local Student Branch.

University of Minnesota. The first meeting of the school year was held on October 12 in the form of a smoker. Talks were given by J. D. Akerman and Wallace Wilcox. The membership of the student branch is at present about sixty. The officers are: Honorary Chairman, John D. Akerman; Chairman, Wallace Wilcox; Vice-Chairman, Donald Lampland; Secretary, Donald Frankel; Treasurer, Allan Raudenbush.

Notre Dame University. The first meeting of the school year was held on September 29. F. N. M. Brown, Head of the Department, was elected Honorary Chairman for the year. Tentative plans were made for a glider club, to be sponsored by the Student Branch. Edward Kelly Grimes read a student paper on wind-tunnel operation and model testing.

Oregon State College. The first business meeting of the school year was held on October 5. Plans were made for the next technical meeting at which the subject for discussion will be "Recent Trends in Aircraft Design." After the business meeting, the films of "Foreign Aeronautical Laboratories" were shown before about 110 students and faculty members of the college.

Rotating Wing Aircraft Meeting

On October 28 and 29, 1938, the Philadelphia Branch of the Institute sponsored a meeting devoted to the problems of Rotating Wing Aircraft. The technical sessions were held at the Franklin Institute in Philadelphia. The meeting was an outstanding success; more than 200 people were present at most of the technical sessions and more than 100 attended the banquet. At a regular meeting of the Franklin Institute on Thursday evening, October 27, Alexander Klemin of New York University delivered a lecture entitled "Rotary Wing Aircraft." The program of the technical sessions of the meeting was as follows:

October 28

10:00 a.m.

Ralph H. McClarren, The Franklin Institute, "Review of Rotating Wing Aircraft."

10:30 a.m.—Development and Improvement

Alexander Klemin, Chairman

Richard H. Prewitt, Kellett Autogiro Corporation, "The Autogiro."
Gerard P. Herrick, Vertoplane Development Corporation, "The Convertaplane."
H. H. Platt, New York, "The Helicopter."
E. Burke Wilford, Pennsylvania Aircraft Syndicate, "The Gyroplane."

2:00 p.m —Application and Uses

W. Wallace Kellett, Chairman

Frank J. G. Dorsey, U. S, House of Representatives, "Military Uses."
A. G. Galloway, U. S. Dept. of Agriculture, "Agricultural Uses."
H. F. Gregory, Air Corps, "Army Experiences."
John M. Miller, Kellett Autogiro Corporation, "Piloting Technique."
James G. Ray, "Unique Uses."

Saturday, October 29

9:30 a.m.—Research Programs

George W. Lewis, Chairman

Alexander Klemin, "New York University."
Montgomery Knight, "Georgia School of Technology."
R. A. Bailey, "National Advisory Committee for Aeronautics."

10:30 a.m.—Future Types and Developments

E. Burke Wilford, Chairman

Louis Breguet, "The Helicopter in Europe."
Raoul Hafner, "The Hafner Gyroplane."
Paul E. Hovgaard, Curtiss Aeroplane Company, "Future Types of Gyroplanes."
Max M. Munk, Washington, D. C., "High Speed with Safety."
W. Laurence LePage, Philadelphia, "Helicopter Performance."

Air Transport Meeting

At the last Annual Meeting of the Institute the section devoted to Air Transport problems was so successful that the Council decided to give this subject a wider scope than is possible at an Annual Meeting.

Accordingly a two-day meeting, devoted exclusively to problems of Air Transport, is being held in Chicago on November 18 and 19, 1938. The program of the technical sessions of the meeting is as follows:

Friday, November 18

10:00 a.m.

William Littlewood, Chairman

Arthur E. Raymond, Douglas Aircraft Company, "Flight Testing the DC-4."

Wellwood E. Beall, Boeing Aircraft Company, "Design Aspects of the Boeing Transatlantic Clipper."

George A. Page, Jr., Curtiss-Wright Corporation, "The Curtiss-Wright 20."

2:00 p.m.

J. A. Herlihy, Chairman

George E. Woods Humphery, formerly of Imperial Airways, Ltd., "Problems of International Air Transport."

A. D .Tuttle, United Air Lines Transport Corporation, "Aeronautical Physiology."

Symposium on Air Transport Operating Problems

L. G. Fritz, T.W.A., "The Economics and Problems of High Altitude Operation."

Charles Froesch, Eastern Air Lines, "The Economics of Local Schedule Operation."

R. E. Johnson, Wright Aeronautical Corporation, "The Possible Advantages of Constant B.M.E.P. Engine Operation."

Discussion by William Littlewood, American Airlines; J. A. Herlihy, United Air Lines Transport Corporation.

Saturday, November 19

10:00 a.m.

L. G. Fritz, Chairman

Lloyd Espenschied and R. C. Newhouse, Bell Telephone Laboratories, "The Terrain Clearance Indicator."

Melvin N. Gough, National Advisory Committee for Aeronautics, "Notes on Stability from the Pilot's Standpoint."

2:00 p.m.

Charles Froesch, Chairman

Charles H. Colvin, Kollsman Instrument Company, "Flight Altitude Control."

J. Lyman and F. C. Moseley, Sperry Gyroscope Co., "Instruments for Instrument Landing."

J. A. Herlihy, United Air Lines Transport Corporation, "Economics and Engineering in Air Transport."

Personnel Opportunities

The Personnel Bureau serves organizations seeking to employ aeronautical specialists as well as individual members. The Bureau has been the means of arranging several very successful connections for members.

Any member or organization may have requirements listed without charge.

Available

Engineer, age 30, M.I.T. graduate, with $6^1/_2$ years' experience in aeronautics in the capacity of draftsman, stress analyst, and designer, wishes to make a new connection. At present employed as Chief Stress Analyst on modern pursuit type airplane. Familiar with U. S. Army requirements. Eastern location preferred. Available December 1st. Write Box 75, Institute of the Aeronautical Sciences.

Books Received

The Institute acknowledges, with appreciation, receipt of the following books for the Institute library.

Die Amerikafahrt des "Graf Zeppelin," by Hugo Eckener; Verlag August Scherl, Berlin, 1928, 114 pages. Gift of H. A. Scholle.

L.Z. 127, Graf Zeppelin, by W. Langsdorff; H. Bechhold, Frankfort, 1928, 80 pages. Gift of H. A. Scholle.

Air Defense, by E. B. Ashmore; Longmans Green, London, 1929, 179 pages. Gift of H. A. Scholle.

Technical Aspects of the Loss of the U.S.S. Shenandoah, American Society of Naval Engineers, 1926, 208 pages. Gift of H. A. Scholle.

Travels in the Air, by J. Glaisher; Richard Bentley, London, 1871, 398 pages. Gift of H. A. Scholle.

Mit Graf Zeppelin um die Welt, by M. Geinenheyner; Societäts Druckerei, Frankfort, 1929, 112 pages. Gift of H. A. Scholle.

Souvenirs et Récits d'un Aerostier Militairs de l'Armée de la Loire, by G. Tissandier; Maurice Dreyfous, Paris, 1891, 356 pages. Gift of H. A. Scholle.

Fünfundzwanzig Jahre Zeppelin Luftschiffbau, by L. Dürr; V. D. I. Verlag, 1924, 83 pages. Gift of H. A. Scholle.

Die Physikalischen Grundlagen der Hohennavigation, by K. Bassus; R. Oldenbourg, München, 1917, 161 pages. Gift of H. A. Scholle.

La Navigation Aerienne du "Belgica," by E. Demuyter; Expansion Belge vers Levant, Bruxelles, 136 pages. Gift of H. A. Scholle.

Fundamentals of Ballooning, by C. H. Roth; Goodyear Tire & Rubber Company, Akron, 77 pages. Gift of H. A. Scholle.

Aviation, by Ernest E. Walker; Aeronautics Education Foundation, 1927; 127 pages. Gift of the author.

Book Reviews

Aeronautical Meteorology, by GEORGE F. TAYLOR; Pitman Publishing Corporation, New York, 1938; 429 pages, $4.50.

Formerly Chief Meteorologist of American Airlines, Inc., and at present Chief Meteorologist of Western Air Express Corporation, Dr. Taylor is well equipped by experience to write the type of book suitable for airline meteorologists and has produced a volume which should be of considerable interest to the general reader as well. However, in writing a "thoroughly practical book," Dr. Taylor has purposely omitted almost all mathematical treatment; although in certain places a simple mathematical analysis would have a real explanatory value and render the book more complete for the serious student. For example, in the discussion of altimetry a simplified treatment of the hydrostatic equation would seem to have a definite place.

The first four chapters form what amounts to an introduction to the more detailed parts of the book on the synoptic work. The opening chapter describes the structure and composition of the atmosphere and presents a brief view of the radiation processes involved. The second chapter, on observational material, gives a good general description of the weather elements and methods of observation with numerous illustrations of the types of instruments favored in airline work.

The next chapter, on thermodynamics, suffers from oversimplification to the extent of inaccuracy. On page 43 there are several misleading statements in the paragraph headed Potential Temperature, "For meteorological purposes it is often desirable to compare the temperatures of the air at localities which are at different elevations, and thus at different pressures. Since, as has been shown above, *the temperature of the air is directly proportional to its pressure*, it is obvious that it will be greatly affected by changes in elevation. If the temperatures of the air at various elevations are to be compared, therefore, it is essential that all temperature readings be reduced to a common *elevation*, . . . when the *1000 millibar level* is used as the *common elevation* . . . ." Note the confusion of elevation and pressure. Again in this chapter, pages 52–53, the description in the text and diagram (Fig. 20) of the adiabatic chart do not agree, the figure does not represent a diagram with ordinates of "pressure on a logarithmic scale, decreasing upwards." It can be seen at a glance that the dry adiabats on this diagram are straight lines and, therefore, the ordinates are the 0.288 powers of the pressure. Figure 28 is, for the same reason, not a true representation of Refsdal's Emagram and areas on the diagram reproduced (Stüve ordinate) "represent work" (page 64) *only approximately*.

The fourth chapter on circulation, contains a brief description of the Bjerknes' Circulation Principle and a derivation of the gradient wind equations essentially in Dr. Humphrey's simplified form leading up to an account of the observed circulations on the earth. The following four chapters are devoted to a detailed treatment of air masses, Chapter 5—General, Chapter 6—North America, Chapter 7—Asia, Chapter 8—Europe. The discussion of the North American air masses departs from the author's avowed intent "to present fairly all sides of most questions." (Introduction XIV.) The designations of the air masses employed are those of Prof. H. C. Willett modified by Dr. I. P. Krick by the addition of subscribed figures to indicate the number of days after leaving the source region or number of days of travel over modifying terrain. It should be mentioned that a great number of synoptic meteorologists who are active in air mass analysis regard these subscripts as an overrefinement which is in general not warranted by the available knowledge of the air-mass trajectories.

Chapters 9, 10, and 11 give a good account of the types of discontinuity surfaces in the atmosphere (fronts), their formation (frontogenesis) and the structure of the extratropical cyclone. Chapter 12 embodies a treatment of thunderstorms and a brief mention of tornadoes and hurricanes.

In the next chapter on clouds, it is pleasing to note that the illustrations of cloud types are far superior to those of the average meteorological text, the majority of these are reproduced in color from the International Cloud Atlas. Having particular aeronautical significance, fog and stratus clouds are taken up in some detail in Chapter 14.

The following four chapters carry the reader through the mechanics of making a synoptic weather map, its analysis, and finally to forecasting from the map and forecasting from local indications. The chapter entitled "Forecasting" is devoted almost entirely to an account of Pettersen's Method of making kinematical and dynamical computations in a field of pressure and no mention is made of the practical application to forecasting of the air-mass concept which has been treated earlier in the book in such detail.

The final chapters deal with a description of the organization of airline meteorological departments and flight dispatching with a short account of the climatological factors influencing the location of airways and airports.

The appendix includes a short meteorological glossary and a number of useful tables. Table 24 (International Weather Symbols) is not up-to-date. The lists of references at the end of each chapter will be extremely helpful to the reader who wishes to pursue the subject in greater detail.

ATHELSTAN F. SPILHAUS
New York University

Practical Air Navigation, by THOBURN C. LYON; U. S. Department of Commerce, Coast and Geodetic Survey, Publication No. 197, Washington, Second (1938) Edition; 181 pages, $0.50.

The recent U. S. Department of Commerce publication No. 197 on "Practical Air Navigation" is far superior to the former and original publication by the Coast and Geodetic Survey Division. The material covered includes numerous charts and diagrams which enable the pilot to readily adapt this book to actual practice.

The introduction covers the listing and available sources of both sectional, regional and radio direction charts. All airmen should have a thorough knowledge of these principles, and it is covered most completely in this publication.

The chapter on cross-country flying goes into this type of navigation most completely, and with a reasonable amount of practice, any individual should be able to fly from point to point with little danger of getting off his track. Naturally, this is only of value where we know the terrain and weather conditions are favorable.

With more extended flights and over strange territory, the pilot resorts to dead reckoning. While this type of navigation from its name may appear to be guess work, it is comparatively accurate. The chapter which covers this phase of navigation explains fully the principles and is well written so that little difficulty will be encountered in understanding it. The plotting of courses on different charts and the measuring of true courses is readily understood. Variation, deviation, the magnetic and compass heading is fully described and although it is a difficult subject to comprehend, is explained in a superb manner. The phase of work covered in the correction for wind drift and the solution of ground speed problems is fully described and with a certain amount of practice, any person should be able to follow a course successfully.

On the subject of Radio Flying, some detail has been omitted although with the new developments no book can be entirely up-to-date. General classifications have been well described, but for a layman pilot to put this type of navigation into practice, more extensive study should be followed before beginning actual radio flying.

Celestial Navigation, while a deep and somewhat intricate subject, is carefully covered. This work will aid greatly any individual interested in this type of work, but actual practice and calculations must be had in order to obtain a complete understanding of this portion of navigation.

The chapter on Meteorology gives the details and reasons for various weather conditions, and describes the sources of information available to the pilot. The reading and understanding of the weather map is somewhat vague, although it is covered sufficiently to enable the pilot to interpret the major conditions that may arise.

With the practical examples in the final chapters of this book, it is possible for a person to have a good general understanding of the entire subject of navigation, and this publication is by far the finest work of its kind ever produced.

The size of the book and the available source of supply makes this volume almost a necessity to the entire flying personnel of the aviation industry.

The author has presented this work in an interesting manner and, without doubt, deserves the thanks of the entire aviation industry for the excellent portrayal of his subject.

KENNETH B. KNOX
Casey Jones School of Aeronautics

Through the Overcast, by ASSEN JORDANOFF, illustrated by Frank L. Carlson and Fred L. Meagher; Funk and Wagnalls Company, New York, 1938; 348 pages, $3.00.

In this book the author has demonstrated, as he did in his earlier book "Your Wings" that he has a rare gift of presenting technical matter in a simple, understandable style. Not only does he write in a readable manner, but the 319 figures spread throughout the text, effectively illustrate concepts which, when presented in the abstract, can be quite difficult to comprehend. These figures represent the structure about which the text is built. Such concepts as convective instability within an air mass, potential temperature and equivalent potential temperature and many others are made clear by the illustrations and the accompanying text.

The method of presentations rather than the newness of the contents is the outstanding feature of the book. Starting with a general presentation of all phases of weather phenomena which are usually embraced under the term Meteorology, Mr. Jordanoff devotes a chapter to each of the instruments that contribute in any way to blind flying. There follow sections on the airplane engine and its characteristics, radio and the technique of instrument flying, and celestial navigation.

The first 130 pages are devoted to Meteorology covering all of the aspects of use to the pilot. The fundamental principles of stability and instability in their various phases, and the physical processes bringing about turbulence, clouds, icing, fog, and thunderstorms are treated exhaustively within the scope of the book. The technique of drawing weather maps and the interpretation of teletype weather reports are described.

The section on instruments is likewise excellent. The functioning of the air speed indicator, the sensitive barometers, including corrections for the temperature, turn and bank indicators, tachometers, compasses, and gyro instruments are explained in detail.

The power plant, engine performance curves, instruments, and fuels and lubrication are all described for the pilot.

The section on radio takes up in detail the principles of the radio compass and technique of airway radio flying and orientation.

For any young man who is planning to become an air transport pilot, there is probably no better book than this to let him know the many phases of "blind flying" that he will have to become familiar with after he completes his flight training. The author has been flying since 1912, and has in this book given other pilots the benefit of not only his experience but of his intensive study in methods of simplification.

Listen! The Wind, by ANNE MORROW LINDBERGH; Harcourt, Brace and Company, New York, 1938; 275 pages, $2.50.

After reading this book one can only come to the conclusion that Anne Morrow Lindbergh is a rare person—a flyer who is not only articulate, but poetic in the recital of her experiences. Even when she writes about the most prosaic event she imbues her description with a poetic style and imagination which earns her a high place among contemporary writers.

The book covers only a brief portion of the flight which she and Colonel Lindbergh made, extending from New York to Europe by way of Greenland, around Europe, and back by way of South America. She has limited her book to a ten day interlude off the African coast, and the flight across the Atlantic to Brazil.

The title is well chosen, for throughout the book the reader feels the importance of the weather and particularly of the wind in determining and altering their flight plans. At Porto Praia the wind blew relentlessly and unceasingly, necessitating a return to the African coast for a take-off for South America. At Bathurst there was too little wind for the heavily loaded plane to get off. After three heartbreaking attempts the take-off was finally accomplished.

Anne Lindbergh has not lost her sense of awe and wonder at the miracle of flight. She includes such small details that the reader feels as though he were with her, experiencing her elation at the sight of a ship, or her nameless and momentary fear of the squall clouds.

Technical aviation people will read between the lines and be impressed by the great skill, patience, and determination which have made the flights of Colonel Lindbergh such examples of perfect performance. An appendix gives a complete record of the flight and a detailed inventory of the innumerable items which are necessary to equip such an exploratory expedition. This portion of the book is, in itself, a revelation.

Before this review appears the book will undoubtably be a "best seller" and will be widely read, not only by air enthusiasts, but by those who admire the style which Mrs. Lindbergh has acquired. The sympathetic and imaginative presentation mark it as a literary work of rare quality.

Menace of the Clouds, by L. E. O. CHARLTON; William Hodge and Company, Ltd., London, 1937; 295 pages, 12s. 6d.

It is unfortunate that the classic book by the Italian General Douhet, "La Guerre de l'Air" has not been translated into English and published. As the earliest and most quoted proponent of the coming supremacy of air power, it is natural that all writers who discuss air strategy and tactics should draw more or less on his emphatic claims. While he does not go into as much detail as the Italian military expert, Air Commodore Charlton gives an up-to-date interpretation of the invincibility of air power. He frankly admits that his views are "heretical."

When he was British Air Attaché in Washington he made many friends in this country. This is the third book he has written since then, all of them intended to stir the lethargy of the English people to greater preparation for a war in the air.

In the opening chapter the author traces the trend of history since the beginning of naval warfare, first in the Mediterranean and later in the Atlantic and Pacific Oceans. He believes that the next great change in strategy is that brought about by air

warfare, *i.e.*, a change from two- to three-dimensional conflict. He discusses the requirements for preparedness in the air and stresses the fact that "equal air forces" does not confer "equal powers of offense" on two countries. An important factor is the respective distances from the boundaries of one country to the industrial and population centers of the other.

In a world survey he places all countries into two groups, the "Haves" and the "Have Nots." In a careful political and geographical analysis he describes the aspirations and objectives of each of the great powers. While the book was written before the Austrian and Czechoslovakian conquests it gives readers, particularly Englishmen, a summary of the problems confronting every country of the world as a result of the sudden expansion of air power.

The chapter on the possible defenses against aircraft is particularly complete. It treats interceptor airplanes, anti-aircraft, balloon barrages, evacuation of cities, as well as other measures. His conclusion is that, in spite of these precautions, the bomber will usually get through.

For the enlightenment of his countrymen the author examines the position the dominions will occupy in the event of a war in which Great Britain is involved. He concludes that Canada, because of her proximity to the United States, will occupy the safest position. Each of the others will have its own particular problem of defense, the success of which will depend largely on the ability of the British to maintain the life-line of the Empire—the sea route.

The most disappointing part of the book is the conclusion. Instead of urging his country to prepare for defense by its own forces he proposes an "international strategic reserve" composed of air forces from the several member states with an air base in Tunis. While collective security has always been an attractive goal along with disarmament, isolationism, and strength through alliances, it does not seem that the world has reached that idealistic state in which nationalism can be subordinated to another League of Nations theory of security.

LESTER D. GARDNER

Tomorrow's War, by STEPHEN POSSONY; William Hodge and Company, Ltd., London, 1938; 255 pages, 8s. 6d.

When a book takes as its hypothesis that future major wars are impossible because of their complexity and cost, instant interest is aroused. There have been many measures of a preventative character proposed and tried but here is one that should commend itself to the study of statesmen who perhaps are proceeding in their international negotiations on the assumption that the next war will begin in the air and end in the mud as so many military strategists claim.

The author writes from a German point of view, the text having been translated. While the book deals only in part with the role aircraft will play in the "total war" it is filled with shocks and surprises. In an offensive war with 200 army divisions in the field the yearly aircraft requirements are calculated to be 30,000 artillery observation planes, 65,000 bombers, and 39,000 fighters. For a defensive war these numbers would be cut by a factor of about four. When these figures are considered, the objective of the argument becomes apparent. The requirements of personnel, material, and ground equipment of the military and naval forces are shown to be enormous, and the manufacturing facilities alone would almost bankrupt any nation. Using a similar line of reasoning, other military and naval branches are studied and a basis laid for an estimate of the economics of future wars. This is done with a plan for reorganizing state finance and labor so that, in effect, an entire nation will be conscripted in time of war.

If the book were based only on the theories of the author it would be interesting, but the documentation covering 250 references gives supporting data that provide a source of invaluable material as to the nature of the next war. It is not easy to agree with some of the book's statements but in a study which is intended to be provocative such agreement is not to be expected or desired.

High, Wide and Frightened, by LOUISE THADEN; Stackpole and Sons, New York, 1938; 263 pages, $2.00.

If there is any woman pilot in the United States who has a right to claim a place in the development of aviation in this country it is Louise Thaden. For ten years she has been engaged in aeronautical work. She began as an office assistant who was not unwilling to double as a "barker" to attract air field customers, and step by step gained fame by attacking and setting records of many kinds. At one time she held separate international records for solo endurance, altitude, and speed. Winning the Bendix Race gained for her world-wide acclaim as a leading speed pilot, regardless of sex.

Her book is a collection of stories of air field experiences, crack-ups, and flights under widely varying conditions. She has interspersed much of her personal life with particular emphasis on the part her husband has played in her career.

To read this book is to become acquainted with many of the leading women pilots of recent years. She met them all in competition and her pen sidelights on their experiences as well as her own will provide a stimulus to young women who wish to learn to fly.

Her story of the endurance flight when she and Frances Marsalis flew for over eight days, aided by refueling, is one of the most interesting chapters.

Her frankness in admitting her fright in emergencies and the candor with which she tells of critical moments in the air will meet with a responsive echo from all pilots, though they may not be as ready as she is to admit their fears.

Mrs. Thaden not only believes in flying herself but is a member of a flying family. Her husband is an expert pilot as well as an able aeronautical engineer and her children and parents fly with her whenever possible.

Air War, by W. O'D. PIERCE; Watts and Company, London, 1937; 147 pages, 2s. 6d.

There are too few aeronautical books which treat of the social effects of aircraft, both commercial and military. This book lays a foundation for the lay reader by giving a readable history of flight from its earliest beginnings. After a summary of the results of the World War, the author gives what he believes will be the effect of aviation in the next conflict.

In the bibliography the reader is referred to three British aeronautical magazines. A broader viewpoint would have resulted had there been more references to publications of other countries. In this case, the Comet would probably not have been regarded as having "marked a revolution in aeroplane design" or the Heinkel 70 as making the biplane obsolete.

The book closes on a presumptive note. It is deliberately intended to awaken ordinary people to the drift of events with a view to controlling them. It will be necessary to meet the present state of transition by new forces of statesmanship and humanity. Older forms of civilization must undergo a change to meet new conditions, and this book will serve its purpose if it shows the perils ahead.

Exchanges

The Institute exchanges the Journal with many other aeronautical periodicals. They are kept on file at the Skyport in Rockefeller Center, New York City, where members may read them. As readers of the Journal may wish to subscribe to some of them, a list of these periodicals with their addresses is published here. Information regarding subscription prices may be secured from the Secretary of the Institute.

Aero, Maneesikatu 2, Helsingfors, Finland.

Aero Digest, 515 Madison Ave., New York City.

Aeronautica Argentina, Velez Sarsfield 57, Cordoba, Argentina.

L'Aéronautique, 55 Quai des Grands-Augustins, Paris, France.

L'Aérophile, 7 Rue Sainte-Lazare, Paris, France.

The Aeroplane, 175 Piccadilly, London, W.1, England.

L'Aerotecnica, Via delle Coppelle 35, Rome, Italy.

Les Ailes, 77 Boulevard Malesherbes, Paris, France.

L'Air, 71, Champs-Élysées, Paris, France.

Aircraft Engineering, 2 Bloomsbury Place, London, E.C.1, England.

Aircraft Production, Dorset House, Stamford Street, London, S.E.I, England

Air Law Review, Washington Square East, New York City.

American Aviation, Earle Building, Washington, D. C.

Asas, Caixa Postal 1967, Rio de Janeiro, Brazil.

Astronautics, American Rocket Society, 31 West 86th Street, New York, N. Y.

Aviation, 330 West 42nd St., New York City.

L'Aviazione, Corso Umberto 504, Rome, Italy.

Bradshaw's International Air Guide, Surrey St., Strand, London, W.C.2, England.

Boletin de Aeronautica Civil, Calle Azcuenga 923, Buenos Aires, Argentina.

Bulletin du Service Technique de l'Aéronautique, 72 Chaussee de Waterloo, Rhode-Saint-Genese, Belgium.

Bulletin of the American Meteorological Society, Blue Hill Observatory, Milton, Massachusetts.

Bulletin Technique du Bureau Veritas, 31 Rue Henri-Rochfort, Paris (17), France.

Canadian Aviation, Journal Building, Ottawa, Canada.

Contact, Fort Lee, N. J.

Deutsche Luftwacht, Schoeneberger Ufer 46, Berlin W35, Germany.

Der Deutsche Sportflieger, Petersteinweg 19, Leipzig C1, Germany.

Les Fiches Aéronautiques, 6 Rue Galilee, Paris, France.

Flight, Dorset House, Stamford St., London, S.E.1, England.

Indian Aviation, P. O. Box 2361, Calcutta, India.

Interavia, 13, Corraterie, Geneva, Switzerland.

Journal of Air Law, Northwestern University, Chicago.

Journal of the Institute of Engineers, Australia, Science House, Gloucester and Essex Sts., Sydney, N. S. W., Australia.

Journal of Research of the National Bureau of Standards, U. S. Govt. Printing Office, Washington, D. C.

Journal of the Royal Aeronautical Society, 7 Albemarle St., Piccadilly, London, W.1, England.

Journal of Scientific Instruments, 1 Lowther Gardens, Exhibition Rd., London, S.W.7, England.

Journal of the Society of Automotive Engineers, 29 West 39th St., New York City.

L'Ala d'Italia, L'Aquilone, La Rivista di Diritto Aeronautico, La Rivista di Meteorologia Aeronautica, Le Vie dell'Aria, Vilea dell'Universita 4, Rome, Italy.

Letectvi, Celetna 13, Praha I, Czechoslovakia.

Luftfahrt-Forschung, Verlag Oldenbourg, Munich 1, Germany.

Die Luftreise, Lindenstr. 35, Berlin SW68, Germany.

Luftfahrt-Literaturschau, Z.W.B. bei der D.V.L., Berlin-Adlershof, Germany.

Model Airplane News, 551 Fifth Avenue, New York City.

Monthly Weather Review, U. S. Dept. of Agriculture, Washington, D. C.

Motor and Flying, 24 Bond St., Sydney, N. S. W., Australia.

National Aeronautics, Dupont Circle, Washington, D. C.

Official Aviation Guide, 608 S. Dearborn St., Chicago, Illinois.

The Pilot, Grand Central Air Terminal, Glendale, California.

Popular Aviation, 608 S. Dearborn St., Chicago, Illinois.

Proceedings of Institute of Radio Engineers, 330 W. 42nd St., New York City.

Publications Scientifiques et Techniques du Ministère de l'Air, 55 Quai des Grands-Augustins, Paris, France.

Review of Scientific Instruments, 175 Fifth Ave., New York City.

Revue de l'Armée de l'Air, 55 Quai des Grands-Augustins, Paris, France.

Revue du Ministère de l'Air, 71 Avenue des Champs-Elysees, Paris (8), France.

Rivista Aeronautica, Ministero dell'Aeronautica, Rome, Italy.

The Royal Air Force Quarterly, Gale & Polden Ltd., 2 Amen Corner, London, E.C.4, England.

Schweizer Aero-Revue Suisse, Gubelhangstrasse 22, Zürich-Oerlikon, Switzerland.

Soaring, 1614 Delaware Ave., Wilmington, Del.

Southern Flight, Ledger Building, Fort Worth, Texas.

Sportsman Pilot, 515 Madison Ave., New York City.

Technical News Bulletin of the National Bureau of Standards, U. S. Govt. Printing Office, Washington, D. C.

Technika Lotnicza, Czerwonego Kryza 21/23 m.6, Warsaw, Poland.

Technika Vosdushnogo Flota, U1. Radio 16, Moscow 16, U. S. S. R.

La Technique Aéronautique, 2 Rue Blanche, Paris (9), France.

U. S. Air Services, Transportation Building, Washington, D. C.

Western Flying, 420 S. San Pedro St., Los Angeles, California.

Wirtschaft Technik Verkehr, Alte Jakobstr. 148/155, Berlin, SW68, Germany.

Zeitschrift für angewandte Mathematik und Mechanik, Kulmstr. 1, Dresden A24, Germany.

AERONAUTICAL REVIEWS

These brief reviews of recent articles on aviation subjects are published by the Army Air Corps for the information of its officers, and are printed here each month by permission of the Chief of the Air Corps

Aerodynamics

Modern Diffuser Design. G. N. Patterson. Efficient transformation of kinetic energy into pressure. Spiral flow with a vortex type of rotation may be transformed most efficiently in the annular space between two similar coaxial cones. Angle between diverging walls for maximum efficiency is 6° to 8° for a conical duct, 6° for a diverging duct with square section throughout, and 11° for rectangular duct with one pair of walls diverging. A length of duct following a diffuser improves efficiency.

Results of investigations are surveyed in such a way as to make them more available to the designer and to indicate an improved basis for the design of diffusers. Discussion covers: factors affecting efficiency; effect of curvature on separation of flow; deflectors for varying both pressure and velocity in the boundary layer regions; suction of the "tired" air in the boundary layer; spiral flow with a vortex type of rotation; spiral flow with "rigid body" rotation; method of designing deflectors for a given rotation; and design modifications which must be made to obtain good efficiency at larger angles of expansion. Long article published with permission of the British Air Ministry. *Aircraft Engineering*, Sept, 1938, pages 267–273, 17 illus., 5 tables, 14 equations.

The Manipulation of the Boundary Layer. E. G. Richardson. Paper and discussion by N. A. V. Piercy, A. Fage, W. G. A. Perring, A. A. Hall, and others. *Journal Royal Aeronautical Soc.*, September, 1938, pages 816–838, 18 illus.

Electric Test Stands for Aerodynamic Investigations. E. Loetterle. New special drives developed for aerodynamic test installations. Test stands used in propeller development and performance measurements, and the large centrifugal stand for testing the mechanical strength of propellers are described. By use of a pole-changing connection and armature control with an a.c. motor of 2600-kw. output, a control range from 750 to 3000 r.p.m. is obtainable and any arbitrary set r.p.m. is maintained constant by an automatic control. Centrifugal motor can be braked rapidly by d.c. excitation of the frame coils.

Motor-driven fan blowers used in wind tunnels are also described, and by an example of a 2000-kw. wind-tunnel motor, it is demonstrated how large motors can be installed in wind tunnels for obtaining suitable flow conditions. In the case of still greater output, r.p.m. control has been attained by means of grid-controlled amplifiers. *E.T.Z.*, July 14, 1938, pages 743–744, 6 illus.

Aircraft Design

The Highly-Loaded Airplane. G. Madelung. Estimate of technical achievements. The author endeavors to show whether the opinion as to the inability of the airplane to carry extensive loads on long-distance flights is justified, or whether the airplane is able to meet the requirements of long-distance travel, that is, to carry extensive loads in extensive spaces in the airplane over long distances. Discussion covers: sufficiently small traffic units, sufficiently useful load and useful room, and sufficiently wide distances; criticism of requirements; distance formulas and modulus; lift/drag ratio; residual drag/thrust; lift/drag ratio of wings and airplanes; structural weight and useful load; and distance modulus and weight ratio. *A.T.Z.*, August 25, 1938, pages 337–340.

Towards the Venetian Blind. R. S. Hall's article in the August issue of "Aero Digest," describing the results obtained with the latest type of improved Hall wing, is quoted and discussed in detail. Parts of his article in the "Journal of the Aeronautical Sciences," August, 1937, are also quoted. Reference is made to results obtained by Errington of Airspeed (1934) Ltd. in connection with the behavior of the low-wing Envoy with flaps during take-off. *Aeroplane*, August 31, 1938, pages 260–264, 12 illus.

Lateral Stability of Flying-Boats on Water. Capt. E. DeG. H. Bromhead. In the proposed design a universal joint gives the float freedom of movement in a vertical and horizontal plane. The tail fin keeps the float automatically head on to the flow of the water, and in the air head to the wind. Small stub wings give the float the necessary longitudinal stability in the water. Otherwise, as the float is free on the universal joint, it would be inclined to hunt in the water. Short description. *Aeroplane*, August 31, 1938, page 265, 3 illus.

Controllability of the Longitudinal Motion of Airplanes. E. Mettler. Flight path of the longitudinal motion of an airplane is determined by means of data on its angle of inclination as a function of the arc length. Through the introduction into the motion equations under the assumption of a constant drag coefficient, by means of simple integrations and differentiations, the control required for an airplane for a given flight path can be determined as a function of arc length. Report of Hanover Technical College. *Luftfahrtforschung*, July 6, 1938, pages 345–353, 14 illus., 30 equations.

Research Reports and Memoranda. "Contingency Coefficient in the Pull Out from a Nose Dive," General A. Fiore. "Actual Status of Research on the Effects Exerted by Accelerations on the Human Organism," P. A. Gemelli. "Field of Motion in a Compressible Fluid," C. Ferrari. "Theory and Experiments on the Phenomena of Wing Flutter," P. Cicala. "Calculation of the Loads in Wing and Tail Units in the Pull Out from a Nose Dive," Capt. G. Schepisi. "Aerodynamic Action on an Oscillating Profile in a Compressible Fluid at Supersonic Speed," C. Possio. "On the Possibilities of the Biplane," L. Poggi. "Flight in Gusts," S. G. Santangelo. "Interference Drag in Wind Tunnels with Open Sections," E. Pistolesi. "Some Difficulties in Carrying Out Aerodynamic Experiments at Speeds only Slightly Exceeding That of Sound," C. Ferri. "New Views and Experiments on Direct Dynamic Lift," A. R. Tripodi. Very brief abstracts of papers presented at the Congress of the Associazione Italiana di Aerotecnica, from "L'Aerotecnica," April. *Aircraft Engineering*, September, 1938, page 290.

Transport Efficiency. L. E. Baynes. Criticism of the new basis of comparison of speed range, load-weight ratio, load-distance ratio, power-weight ratio, and power-passenger ratio in the commercial airplane specifications which were given in the recent transport issue. The first three are considered of interest provided all other factors are taken into account, but power-weight and power-passenger ratios, are called misleading and not based on correct assumptions. A figure of disposable load times square of the cruising speed divided by cruising horsepower is preferred as an economy usefulness factor of an airplane and this figure is given for 21 representative commercial airplanes with a second rating for metal construction, equipment, and accommodation. *Aeroplane*, September 21, 1938, page 357.

Stress Analysis and Structures

The Continuous Beam. S. J. E. Moyes. Criticism by W. Tye of an article in the August issue, and answer by the author. An error in an article entitled "Monoplane Wings with Sweep," by J. R. Crean from the same issue, is corrected. *Aircraft Engineering*, September, 1938, page 281.

Load Carrying Width of Curved Sheets after Buckling. W. A. Wenzek. Tests for determining load capacity, or stress-bearing width, of circular curved sheets at pure compressive stress. According to the results, a relation for the load carrying width of curved sheets is given. These results are compared with those obtained by the D.V.L. and are found to conform satisfactorily. Test equipment and results obtained are illustrated. Report of the Berlin Technical College. *Luftfahrtforschung*, July 6, 1938, pages 340–344, 14 illus., 1 table, 4 equations.

Riveting Methods and Rivet Equipments Used in the German Light Metal Aeroplane Construction. W. Pleines. Heinkel explosive riveting methods are discussed in great detail in a supplement not given in the preprint. Points covered include: rivet design; requirements of explosive; riveting method; correct setup for the heating tool; electrically heated tool; convenient ratio of rivet length and sheet thickness; dimensions for explosive rivets with flat round closing heads; special rules for riveting long rivet seams and structural parts, walls of which are near the opposite closing heads of explosive rivets; and rivet materials and their treatment preferred in Germany. FMA automatic repetition riveting machine and its operations of automatically drilling, countersinking (with cutting attachment), or "dimpling" of sheets, insertion of rivets, and driving and heading of rivets in one vertical axis without displacement of the work are described in great detail. Riveting times necessary for driving one rivet into a wing according to its accessibility and special shape of rivet and rivet joint as parameters are shown in a graph. *Journal Royal Aeronautical Soc.*, September, 1938, pages 761–797 and (Suppl.) 798–815, 46 illus., many tables.

The National Physical Laboratory. Research on the strength and stability in structures which embody panels of thin sheet metal under stress, such as aircraft structures, is discussed. Underlying idea of the Laboratory's analysis has been to interpose between the monocoque and the concentrated load some form of integrating structure to distribute the load over the whole width of the monocoque and so to enable the latter to be used efficiently. Three types of integrating structure which are being considered are briefly described. Results of an analysis of the stability of a plane rectangular grid made up of stringers and ribs, of which the stringers are subject to uniform compressive loading, are referred to. Research on roads, vehicle-wheel impacts, and strength tests on ships' plating is also taken up. Research being undertaken by the Engineering Department. *Engineering*, August 5, 1938, pages 151–152, 1 illus.

Aircraft Accidents

An Educative Accident. Accident to the DeHavilland Albatross long-range mail-carrier aircraft which was undergoing take-off and landing tests of an exceptionally severe nature. It was loaded up to 3000 lb. more than the maximum all-up weight of the Certificate of Airworthiness for tests in preparation for transatlantic service. After the third landing the aircraft had practically come to rest when a failure occurred in the fuselage structure just aft of the trailing edge of the wing. Official announcement of the company and a few details of the accident are reported. It is said that "several Douglas fuselages have been kinked because the pilots have landed them tail up, have put on their brakes, and dropped the tail hard. A tail down landing might also break a long fuselage. That is why the Douglas Company have taken to a tricycle undercarriage. But that also has disadvantages, and perhaps the right remedy is a pair of retractable tail wheels part way towards the tail." The Albatross is entirely of wood construction. *Aeroplane*, August 31, 1938, page 249.

Brief note and editorial on the accident to the Albatross. *Flight*, September 1, 1938, pages 184 and 176.

The Report on the Accident to the Empire Boat "Cygnus." Incorrect setting of the flaps during take-off is reported as the cause of the accident to the Cygnus flying boat in the Harbor of Brindisi last December. The captain attempted to take off with the flaps in the "full out" position as full routine instructions for take-off had not been carried out and checked. Trials with another flying boat of the same type showed that under similar conditions the aircraft would "porpoise" and if the porpoise was not immediately checked, the boat would quickly become out of control. Abstract of report of Chief Inspector of Accidents, British Air Ministry. *Aeroplane*, August 31, 1938, page 266. *Engineer*, September 2, 1938, page 253. *Flight*, September 1, 1938, page 184.

Aircraft Alighting Gear

Strip Aerodromes—A Practical Possibility? Maclaren "crabbing" undercarriage, which is being tested on the Arpin monoplane, is considered from the standpoint of the runway problem. Tricycle undercarriage is directionally adjustable on the ground to an angle suitable for prevailing conditions, and in actual practice the degree of crab would be adjustable from the pilot's seat. Wheels are merely adjusted so that the airplane can continue without swing down the runway strip at the touch-down drift angle. Front wheel remains steerable. Operational points, long-range possibilities, and angle adjustment are discussed. *Flight*, September 1, 1938, pages 178–180, 176, 4 illus.

Short description. *Aeroplane*, August 31, 1938, page 264, 2 illus.

Steerable Tail Wheel and Tire. Aircraft Associates steerable and automatic full swiveling tail wheel and solid tail-wheel tire. Tail wheel may be set so that it is steerable, and becomes automatically full swiveling when the ship is turned shorter than in a normal turn. Automatic device is adjustable and the wheel can be set to swivel at any desired point. Few details. *Aero Digest*, September, 1938, page 85, 1 illus.

Aircraft Vibration

Vibration in Aircraft. B. C. Carter. First issue—Aircraft vibration due to aerodynamic and non-aerodynamic causes; the propeller as a source of periodic disturbances; whirling vibration; torsional vibration of crankshaft-propeller systems; and propeller-blade vibration. *Engineering*, August 26, 1938, pages 256–258, 3 illus., 3 tables.

Second issue—Mechanical and optical means of investigating vibration in relation to aircraft, results of some vibrograph investigations, modern electrical methods of recording vibration, and the photocell torsiograph are described in detail, including: the modified Cambridge vibrograph; Royal Aircraft Establishment vibrograph developed specifically for aircraft use; curve of frequency against amplitude which defines the threshold of unpleasant vibration; D.V.L. torsiograph; R.A.E. Mark Va torsiograph for use in aircraft engines; and R.A.E. methods for obtaining photographic records of propeller blade-tip vibration relative to the hub under running conditions and for recording vibrations on the test rig. British Association paper. *Engineering*, September 2, 1938, pages 284–288, 278, and (discussion) 282–283, 21 illus, 4 on suppl. plate.

Aircraft

The First International Aircraft Show at Belgrade. G. W. Feuchter. Jugoslavian Ikarus, I.K.II and I.K.III single-seater fighters, Zmaj R-1 two-seater fighter and light bomber, and Rogozarski R-313 medium bomber. Italian Macchi C.200 single-seater fighter, and Breda 88 multi-seater fighter and medium bomber; Polish P.Z.L. 37 heavy bomber. Czechoslovakian Avia F.IX-1, Avia 35 single-seater fighter, and Avia 158 bomber. Some specifications of these aircraft and reference to aircraft and antiaircraft weapons and bombs exhibited. *Luftwehr*, July, 1938, pages 290–297, 24 illus. *Luftwissen*, July, 1938, pages 241–248, 25 illus., 1 table.

Two articles by F. Wittekind describing the aircraft, engines, and equipment exhibited at both the Jugoslavian and Finnish Shows. *A.T.Z.*, July 25, 1938, pages 377–380, 7 illus.

Something of Most Things. Photographs include: Sikorsky S-42-B 42-passenger flying boat; Airspeed Oxfords (two Armstrong-Siddeley Cheetahs) used for transition training between single- and twin-motor training; rear view of the Boeing bomber; Nakajima A.T. ten seater (two 460-hp. Nakajima Kotobuki radial engines); Brewster XF2A-1 single-seater fighter; Noorduyn Norseman monoplane being supplied to the Royal Canadian Air Force; and the Japanese long-range monoplane which recently set up a record for distance in a closed circuit of 7240 miles. Comment on the Boeing—"The blisters amidships house machine guns, each of which has, obviously, a very limited field of fire. There is another gun-pit under the tail. The flaps and elevators are apparently a species of Flettner control." Short fuselage of the Brewster is criticized. *Aeroplane*, August 31, 1938, page 259, 7 illus.

Bomber Facts and Figures. About 12,500 first-line airplanes could be put into the air by the six most important European powers, and of these about 5000 are bombers. Details of the French, German, Italian, Czechoslovakian, and Russian bombers. Cruising speed, range, and bomb load are given. Gunner's and bomber's positions in the Junkers Ju. 86K aircraft supplied to Sweden are illustrated. *Aeroplane*, September 21, 1938, page 343, 1 illus., 4 tables.

Distance Rumblings. Aspects and activities to do with the breaking of the World's Distance Record. Possible ranges of the British Wellesley (8350 miles overloaded to 165 percent), and the Mercury (6900 miles overloaded to 137 percent); German Do. 26 (8100 miles overloaded to 122 percent); Italian Savoia-Marchetti S.M. 75 (8100 miles overloaded to 168 percent); French Dewoitine long-range monoplane (rumored to have been designed for a range of 12,100 miles); and Japanese long-range monoplane (unlikely to exceed 7450 miles).

"The U. S. A. does not seem interested in the matter although it may have equipment equal to other countries. . . . But the one-and-only Boeing YB-15 would be able to reach about 8100 miles overloaded to about 150 percent to 100,000 lb. cruising at 180 m.p.h." *Aeroplane*, September 21, 1938, page 344.

Canada

Jacobs-Powered Fleet Model 50K. Fleet twin-engined Model 50K biplane accommodating up to 12 passengers is adapted from the "Freighter" recently produced to meet the requirements of Canadian operators. Model 50K has been designed for float or ski operations in restricted areas and under all temperature ranges and is a salt-water-corrosion-proofed steel-braced aircraft of mixed construction. Two 330-hp. Jacobs L-6 engines, landplane maximum speed 150 m.p.h., cruising range 660 miles. Description. *Aero Digest*, September, 1938, page 78, 3 illus., 1 table.

Military Noorduyn. Modified Noorduyn Norseman used as a classroom trainer by the Royal Canadian Air Force (gross weight 6450 lb., landplane maximum speed 170 m.p.h. at 5000 ft., range 600 miles, seaplane maximum speed 154 m.p.h., range 550 miles). Airplanes are arranged for instruction of five or six pilots in use of navigation, bombing, and radio equipment, and can also be used as military transports. Short description of equipment. *Flight*, September 1, 1938, page 184e, 1 illus.

France

France Builds an Asboth Helicopter. An Asboth helicopter with a 180-hp. aircraft engine is being built by a company formed in France for that purpose and should be flying by now. Brief reference. *Aeroplane*, September 7, 1938, page 288.

The LeO 45. Liore' et Olivier LeO.45 bomber (two Hispano-Suiza 14AA 1120-hp. two-row radials) has a top speed of 298 m.p.h., range of 745–1430 miles, absolute ceiling of 27,885 ft., climb to 13,120 ft. in 10 min., and T.V. diving speed of 388 m.p.h. Brief reference. *Flight*, September 1, 1938, page 190.

The New LeO. Prototype of the series of six Liore' et Olivier 24–6 26-passenger 200-m.p.h. flying boats, ordered for the Mediterranean services of Air France, is ready for tests. Four Hispano 12Xi 690-hp. engines are placed in line along the leading edge of the wing. All-up weight 13 tons, range 700 miles, and cruising speed 160 m.p.h. Brief reference. *Flight*, September 1, 1938, page 180.

New Military Aircraft. Bréguet 730 11-seater large flying boat for long-distance scouting and bombing (four Gnôme-Rhône 14-No 14-cylinder 1000/1100-hp. engines, maximum speed 325 km./hr.). Latécoère 525 large flying boat for long-distance scouting and bombing (six Hispano-Suiza 12Y27 885-hp. water-cooled engines, maximum speed 260 km./hr.). Construction and characteristics. *Luftwehr*, July, 1938, page 299, 3 illus., 2 tables.

"Twin" Fighters in Service. "Tests with the new French fighters will throw little light on the turret question, because the rear guns have manually-operated mountings with a limited arc of movement . . . . engines of much higher power will be needed in subsequent designs, for with thirteen hundred horsepower the performance of the Potez is little or no better than that of the Blenheim bomber." Brief editorial. *Flight*, September 1, 1938, page 177.

Airplanes in Test. Morane-Saulnier 406 (Hispano-Suiza 12 Ycrs engine cannon). Dewoitine fighter prototype of the new program (estimated maximum speed around 550 km./hr.). Farman 2230 bomber (four Hispano-Suiza 12 Y.50 engines each developing 1200 hp. at take-off and 1000 hp. at altitude) transports a useful load of 1000 kg. over 8000 km. at a cruising speed of 340 km./hr. In the Marcel-Bloch 151 single-seater fighter prototype (Gnôme Rhône 14 N.11 870-hp. engine) wing surface has been increased to 17.5 sq. meters because of new equipment which raised its total weight to 2600 kg. motorized model of the Payen "Flechair" fighter (two Salmson engines to be coupled to and to drive two concentric propellers rotating in opposite directions). Brief references only to these military airplanes and to the LeO H-47 (four Hispano-Suiza engines giving 3600 hp.) and Farman 2221 "Laurent-Guerrero" (four Hispano-Suiza 12X engines) with a pressure cabin. *Les Ailes*, September 9, 1938, page 9.

The Animated Wing and Dynamic Stabilization. Jacquemin monoplane with "dynamic stability" has a small counterweight at the ends of the wing tips. In the new system the center of gravity continues to pass forward of the point of articulation of the wing which is necessary for damping the oscillations of the wing. Airplane is powered by a 35-hp. engine. Results obtained by A. Jacquemin in flight tests are described. *Les Ailes*, September 15, 1938, page 12, 3 illus.

France's Aerial Cruiser. Tests are now in progress with the Latécoère 525 long-range naval flying boat powered by Hispano-Suiza 12Y27 engines of 885 hp. each, and said to have a top speed around 160 m.p.h. Brief reference. *Flight*, September 22, 1938, page 259.

The Two Hanriot Bimotors. Hanriot H-220 and H-510 in flight. Drawing only. *Les Ailes*, September 15, 1938, page 3.

The N.C.-470 Training Seaplane. A. Frachet. N.C.-470 five-seater twin-float monoplane seaplane prototype (two Gnôme-Rhône 9-AKX 480-hp. engines) which recently passed its tests was developed by Farman and produced by the S.N.C.A. It is intended for training in piloting bimotored seaplanes, gunnery, navigation, bombing, and other missions of a multi-seater. Wing span 24.41 meters; maximum speed 212 km./hr. at 1000 meters, range 6 hours. Performance with two Gnôme Rhône K-9 600-hp. engines also given. *Les Ailes*, September 15, 1938, page 9, 3 illus., 1 table.

Germany

Gotha Go.149. Gotha Go.149 single-seater aerobatic trainer or sport airplane (240-hp. Argus As.10C 8-cylinder inverted 90°-vee aircooled engine) has a top speed of 214 m.p.h. and range of 615 miles at cruising speed of 199 m.p.h. Details, characteristics, and performance. *Aeroplane*, August 24, 1938, page 232, 2 illus., 1 table.

Diesel Seaplane No. 3. New German catapult seaplane Nordstern of the improved Blohm and Voss Ha-139 type (four Junkers Jumo Diesels) flew the 2397 miles from Horta to Port Washington in 13 hr. 4 min. at an average speed of 175 m.p.h. Brief reference. *Aeroplane*, September 21, 1938, page 351.

Another German Twin. Siebel Fh. 104.A (two Hirth V8 engines) which carries five passengers at a sea-level cruising speed of 186 m.p.h. was winner at the third Raduno del Littorio. Photograph only. *Flight*, September 15, 1938, page 234, 1 illus.

Lightweight Twin. German twin-engined airplane built by Gothaer Waggonfabrik and carrying three people at a maximum speed of 125 m.p.h. on two 42-hp. inverted Zundapp engines. Photograph only. *Flight*, September 1, 1938, page 184h.

Focke-Wulf "Condor." Focke-Wulf FW 200 Condor, "Brandenburg," German transport which made the record-breaking nonstop flights between Berlin and New York. Transport is a four-motored cantilever low-wing all-metal monoplane normally accommodating 30 persons and crew of four. The four 720-hp. BMW 132-G Hornet engines are equipped with Junkers controllable-pitch propellers having Focke-Wulf blades and Hamilton-Standard control mechanism. Each engine unit with its complete oil system can be replaced by three men in 15 minutes. Maximum speed 227 m.p.h., cruising speed 197.6 m.p.h. at 1000 ft., cruising range 780-1550 miles. Long description. *Aero Digest*, September, 1938, pages 77–78, 4 illus., 1 table.

Article by K. Tank describes in great detail the performance, construction, engines, fuel tanks, new aids for aircraft control, equipment, wings, fuselage, and alighting gear. Powered by the 870-hp. BMW 132-Dc engines, the flying boat has a top speed of 430 km./hr. Performances with both the BMW 132-G and BMW 132 Dc are given. Cutaway drawing shows construction and location of equipment. *Luftwissen*, July, 1938, pages 257–262, 26 illus., 1 table.

German Plane Makes Record Ocean Crossings. Four German aviators completed one of the most outstanding round trip transatlantic flights last month when they landed their four-motored Focke-Wulf Condor Brandenburg at Tempelhof Airport. They took off from Berlin and after a 24-hr. 58-min. nonstop flight to New York, left two days later and made the return flight in 19 hr. 55 min. with several new records to their credit. Details of flight. *Aero Digest*, September, 1938, page 21, 2 illus.

A Remarkable Dornier Boat. Four engines are arranged in tandem on the Dornier Do.26 flying boat and the pusher engines can be tilted at take-off so as to get the propellers clear of the spray. Do.26 which has been designed especially for North Atlantic mail service, weighs 44,000 lb gross, when launched by catapult, and has a maximum speed of 208 m.p.h., cruising speed of 192 m.p.h., and maximum range of 5600 miles. Retractable wing-tip floats are used and four Junkers Jumo 205 600-hp. engines power the airplane. Description. *Flight*, September 8, 1938, pages 218, 217, 197, 4 illus., 1 table. *Aeroplane*, September 7, 1938, pages 289–290, 275, 3 illus.

Great Britain

Our Long-Distance Record Shot. Vickers Wellesleys which have been reconstructed for the long-distance record attempt and have already been tried out on a flight from Cranwell to the Persian Gulf, will start on their record attempt from Egypt and fly nonstop to Australia. Short note. *Aeroplane*, September 7, 1938, page 279.

A New Hafner Design. A.R. IV two-seater side-by-side gyroplane, which has been designed, should be able to take off with no forward run and climb straight away at an angle of 1 in 3.2 from any space 25×12 ft. with 40-ft. clearance for the rotor. With a 125-hp. Pobjoy Niagara V engine, the design specifies a 18- to 115-m.p.h. speed range in level flight. Description. *Aeroplane*, September 7, 1938, page 290, 1 illus.

Merlin-Engined Whitleys. Whitley airplanes fitted when Merlin IV engines will be known as the Whitley IV, and as the Whitley V when fitted with Merlin X engines. Brief reference. *Flight*, September 1, 1938, page 188.

Imperial Luxury. Passenger arrangements and cockpit of the Empire version of the 27-passenger Armstrong-Whitworth Ensign airliner (four Siddeley Tiger IX engines each giving 880 hp. for take-off). Drawings of the interior. *Flight*, September 15, 1938, pages 224–225, 9 illus.

For the C.A.G. Chrislea Airguard side-by-side low-wing cantilever cabin monoplane (Walter Mikron II 62-hp. four-in-line inverted engine) is said

be suitable as a training airplane for the Civil Air Guard. Maximum cruising speed 110 m.p.h., range 375 miles, and service ceiling 15,000 ft., fully loaded. Long description and drawings of construction.

Photograph of the Mosscraft open two-seater sports model with dual control is given on another page. Pobjoy Niagara III engine, top speed 134 m.p.h., landing speed 38 m.p.h. This airplane is also said to be suitable for the Civil Air Guard. *Flight*, September 15, 1938, pages 237–238 and 239, 12 illus.

Logical Unconventionality. De Bruyne-Maas Ladybird used at Cambridge for trying out ingenious ideas is a shoulder-wing monoplane with tricycle undercarriage and near-bakelite construction. Trailing edge of each of the main undercarriage trousers can be turned to provide air-braking surface. Photograph only. *Flight*, September 8, 1938, page 204.

Hatfield Looks Ahead. A few more details of the DeHavilland D.H.95 12- to 18-passenger transport (two Bristol Perseus XIIC 850-hp. sleeve-valve engines), and photographs showing parts of the airplane under construction. *Flight*, September 22, 1938, pages 251–252, 4 illus.

Photographs of airplane under construction. *Aeroplane*, September 21, 1938, page 334, 2 illus.

Imperial's New Ensigns. Flying trials have shown that the maximum speed of the Armstrong-Whitworth Ensign landplanes (four 880-hp. Armstrong-Siddeley Tiger IX engines) is five miles an hour up on the estimated 200 m.p.h. Maximum cruising speed is 170 m.p.h. at 7000 ft. Revised weights of the Ensign are given in a short note. *Aeroplane*, August 24, 1938, page 219.

The Luton Major. Luton Major high-wing cabin training and touring monoplane. Walter Mikron II 62-hp. engine, maximum speed 100 m.p.h., range 320 miles. Short description. *Aeroplane*, August 24, 1938, page 240, 1 illus.

Mercury's Great Attempt. For the long-distance flight from Dundee to South Africa, the upper component of the Short Mayo composite aircraft has been fitted with extra fuel tanks which increase the capacity from the normal 1180 gal. to 2130 gal. Still-air range is estimated at about 6700 miles. Short note. *Flight*, September 22, 1938, page 249.

Q-ing Up. Percival Q.6 six-seater twin-engined monoplane. Long description of design and flight performance. *Aeroplane*, August 3, 1938, pages 151–152, 4 illus.

A Single-Seater for the C.A.Gs. Taylor-Wilkinson Ding-Bat single-seater low-wing monoplane (32-hp. Carden-Ford water-cooled engine) offered as a training airplane for the Civil Air Guard. Description with a few criticisms. *Aeroplane*, August 24, 1938, page 231, 2 illus., 1 table.

HOLLAND

Fokker D.21 Breaks Dutch Record. Fokker D.21 single-seater (Bristol Mercury VIII radial engine giving 830 hp. max.) was used in the Dutch altitude record flight to 37,250 ft. Airplane was a standard service type carrying a full military load. Brief reference. *Flight*, September 22, 1938, page 259, 1 illus.

Gull-Winged. Koolhoven F.K.57 three-seater light transport monoplane (two 205-hp. D.H. Gipsy Six II engines). At an all-up weight of 4761 lb. maximum speed is 183 m.p.h. Range is 1280 miles at 171 m.p.h. Photographs only. *Aeroplane*, August 24, 1938, page 219, 2 illus.

The Koolhoven 52. Koolhoven F.K.52 two-seater escort fighter biplane (840-hp. Bristol Mercury VIII engine) is designed to accompany bombers in raids and has high maneuverability. It is of mixed wood and welded steel-tube construction. Top speed 236 m.p.h. with full load at 15,600 ft., cruising (at 65 percent of power) 203 m.p.h., and range 703 miles (at 65 percent of power, bomb load (at 65 percent power) 254 lb. for 525 miles. Specifications, description, and flight performance. *Aeroplane*, August 3, 1938, pages 146–148, 7 illus., 1 table.

A Civil Nose. Close-up view of the specially arranged windows in the front end of the Koolhoven F.K.49 survey airplane ordered by the Turkish government. *Aeroplane*, September 7, 1938, page 288.

ITALY

Efficiency from Milan. By use of slots and flaps the Breda 79S four-seater cabin airplane has an exceptionally wide speed range. Maximum speed is 162 m.p.h., stalling speed 47 m.p.h., and range 560 miles. Photograph only. *Flight*, September 1, 1938, page 192, 1 illus.

An Italian Monoplane Fighter. Fiat G.50 single-seater low-wing all-metal monoplane fighter (Fiat A.74 RC.38 840-hp. engine) may be adapted to a number of duties and has alternative gun equipment and a variety of bomb loads, incendiary bombs being to the fore in most cases. Two standard machine guns are mounted in the top of the fuselage and two additional guns can be mounted in the wing. Various bomb loads can be accommodated in the fuselage. Maximum speed 292 m.p.h. at 14,800 ft. Stalling speed with flaps 69.5 m.p.h. Long description and table showing weights and ranges with the six standard sets of armament and other equipment. *Aircraft Engineering*, September, 1938, pages 285–286, 3 illus., 2 tables.

Trimotor Floatplanes at Brindisi. Military version of the three-engined Cant twin-float seaplane has been adopted by the Regia Aeronautica and a squadron is now based at Brindisi. The seaplane appears to be fitted with Alfa-built Pegasus engines and is characterized by a pronounced "belly" for bomb stowage. It should be possible to accommodate a torpedo. Brief reference. *Flight*, September 1, 1938, page 190.

JUGOSLAVIA

An Aerobatic Trainer. SIM-XI single-seat parasol monoplane for advanced aerobatics (160-hp. Bramo Sh-14a 7-cylinder high-compression radial engine) has a maximum speed of 124 m.p.h. and all-up weight of 1500 lb. Photograph only. *Aeroplane*, September 21, 1938, page 346, 1 illus.

A Yugoslav Seaplane. SIM-XIV-H observation seaplane (two 240-hp. Argus As-10C engines, loaded weight 6834 lb., empty weight 4409 lb.). Photograph and span and wing area only. *Aeroplane*, August 31, 1938, page 265, 1 illus.

POLAND

The P.Z.L.-37. P.Z.L.-37 four-seater medium bomber (two 925-hp. Bristol Pegasus XX engines, maximum speed 273 m.p.h. at 12,140 ft., cruising speed 236 m.p.h. at 13,123 ft.). Details of construction, armament, characteristics, and performance. *Aeroplane*, August 24, 1938, page 232, 2 illus., 1 table.

U. S. A.

The 1939 Model of the Aeronca Chief. Improvements incorporated in the Aeronca Chief Model 50-C which is powered with a Continental 50-hp. engine and has a high speed of 100 m.p.h., cruising speed of 90 m.p.h. and cruising range of 250 miles. Description. *Western Flying*, September, 1938, pages 19–20, 1 illus., 1 table.

DC-4 Continues Tests. Program of flight tests which was accomplished with an installation of test equipment weighing 8424 lb. As many as 22 engineers and observers have been carried aloft on these flights. Cabin as rigged for tests is illustrated. Brief note. *Aero Digest*, September, 1938, page 22, 2 illus.

Flight testing program included tests of structure, engine operation, propeller and accessory functioning, airflow about various parts of the plane, and other items. Short description. *Aviation*, September, 1938, pages 36–37, 7 illus.

From the States. Seversky single-seater fighters of the 27th Pursuit Squadron, U. S. Army Air Corps, are shown in formation at the National Air Races, with the comment that "the gun power is believed to be inferior to that of our own (British) monoplane fighters." Photograph only. *Flight*, September 15, 1938, page 230a, 1 illus.

Plywood Airplane. Bennett Executive 7-passenger twin-Jacobs-powered light transport monoplane of all-plywood balloon-cloth-covered construction has a maximum payload of 1584 lb., high speed of 206 m.p.h. with two Jacobs L-5 engines, and cruising speed of 196 m.p.h. at 8000 ft. Description, characteristics, and performance. *Aviation*, September, 1938, page 40, 1 illus., 1 table. *Western Flying*, September, 1938, page 21, 2 illus., 1 table.

An Uncivil Stern. Gun turret and offset tail wheel of the new Sikorsky XPBS-1 four-engined flying boat built for the U. S. Navy are referred to with a photograph of this ship. Photograph of the Consolidated XPB2Y-1 is shown on another page with comment on the twin fins and rudders and wing-tip floats. *Aeroplane*, September 7, 1938, pages 288, 279, 2 illus.

What a Target! "The Boeing XB-15, four 1000-hp. Twin Wasps. Its span is about 150 ft., its wing area is about 2870 sq. ft. In fact it is the kind of target for which the crew of a high-speed twin-motor fighter armed with 37 millimetre cannon would pray." Photograph only. *Aeroplane*, August, 31, 1938, page 246, 1 illus.

A New Transport Aeroplane. Curtiss Condor Model 20 30-passenger transport. Long description, characteristics, and performance. Agreement between Donald Douglas and the airlines is referred to and photographs of the Fowler flaps on the Lockheed 14 are given. *Aeroplane*, August 24, 1938, pages 229–231, 12 illus.

U. S. S. R.

A Russian Bomber. Nose of a twin-motored Russian bomber in Spain. "Apart from the obsolete-looking liquid-cooled engines the machine seems to be a copy of the American Martin Bomber." Photographs only. *Aeroplane*, September 21, 1938, pages 344–345, 2 illus.

Soviet Heavy Bomber SB-1. Photograph only. *Luftwehr*, July, 1938, page 300, 1 illus.

Airships

New Graf Zeppelin. LZ-130 airship is 803 ft. long and has a capacity of about 7,062,000 cu. ft. Cruising speed is about 80 m.p.h. with the 2800 hp. of its four Daimler Benz engines. At present hydrogen is used. Brief note. *Aeroplane*, September 21, 1938, page 333, 1 illus. *Flight*, September 22, 1938, page 256, 1 illus.

On the Non-Inflammable Zeppelin. C. G. Grey.. Necessity for releasing gas through the valves of an airship when descending to lower levels is said to be reduced by use of a new German condenser which supplies water ballast from the engine exhaust gases. Hydrogen will be used on a trial flight of the LZ-130 airship, but I. G. Farbenindustrie is reported at work on a synthetic gas, probably synthesizing, or combining, hydrogen with some other substance which will prevent the hydrogen from combining with oxygen and so forming an inflammable gas. *Aeroplane*, September 7, 1938, page 278.

Balloons

The Balloon Barrage. Major F. A. de V. Robertson. Each balloon envelope can be carried about deflated and neatly packed up on its lorry. When the appointed position is reached a bed can be laid down, the envelope quickly inflated from the cylinders, and the balloon transferred to the winch and allowed to ascend. Balloon capacity is about 20,000 cu. ft. A horizontal stabilizer is located on each side at the tail and a rudder underneath. When envelope is full of gas the ballonets inside the envelope are empty but when gas escapes or is valved they fill with air and keep the balloon in shape. Description of operation of the balloons, and progress revealed at inspection by the British Air Minister. *Flight*, September 15, 1938, pages 230f-231, 5 illus.

Air Transportation

Forty to Fifty Passenger Airplanes Will Be Used Before Long on Airlines. L. Charvet. Trends in commercial aviation and the airplanes of the future are discussed by the assistant to the chief director of Air France. *Les Ailes*, September 15, 1938, page 8, 2 illus.

Empire Return. H. F. King. Detailed account of flights from Southampton down the Australian route in R.M.A. Camilla. Second issue describes the flights over the Karachi-Sydney stretch of the route and return. *Flight*, September 8 and 15, 1938, pages 198–203, 230b–230e, 6 illus.

Germany Grabs Atlantic Spotlight; England Exists Briefly; France Waits Cue. Transatlantic flights and present status of the German, English, and French preparations for air transport services over the North Atlantic. *Aviation*, September, 1938, pages 54–55, 59, 8 illus.

Schedule Maintenance Problems Solved Graphically. R. L. McBrien. Schedule-maintenance chart shown is designed for pilot usage and provides ready solutions for certain speed-time-distance problems. Examples are given for the problems of the plane operating behind schedule and for the plane operating ahead of schedule. *Aero Digest*, September, 1938, pages 65–66, 1 illus., 1 table, 2 equations.

Seaplane? Landplane? Flying Boat? Which Will the Germans Use on Their Trans-Atlantic Service? Survey flights made by Deutsche Lufthansa across the North Atlantic, in which seaplanes, landplanes, and flying boats have been used, and the German technique of catapulting large seaplanes and flying boats are discussed. *Western Flying*, September, 1938, pages 9–11, 5 illus.

United's Modern Headquarters. United Air Lines' modern office building and operations headquarters just east of the Municipal Airport, Chicago. Description of building and medical department equipment. *Aero Digest*, September, 1938, pages 69, 86, 4 illus.

Short description. *U.S. Air Services*, September, 1938, pages 25, 32.

Propellers

Controllable-Pitch Propeller. New type of controllable-pitch propeller, recently patented by E. G. Meijer of the General Electric Company, has an arrangement for changing blade pitch while in flight as air density changes. Mechanism is enclosed in the propeller hub and change in pitch is effected by heat generated by an electric coil, the heat causing metallic cylinders telescoped within one another to expand. These sleeves are connected to the pitch changing mechanism. Description. *Aero Digest*, September, 1938, page 82.

A "Hinged" Propeller. Propeller patented by Lt. Col. W. C. Ocker and Lt. G. R. Smith produces only a fraction of the noise created by other modern propellers. Blades are mounted in a ball and socket joint allowing adjustment to the forces of rotation and thrust without introduction of bending stresses. Brief reference. *Western Flying*, September, 1938, page 32.

Propulsion Groups with Rotating Phase. W. Ernsthausen. Calculations given were made in connection with an investigation of the origin of propeller noise. Field excited by a propulsion group with rotating phase (propeller) and the radiated energy are computed by considering certain radial amplitude distributions. Report of the D.V.L. Institute of Electrophysics. *Luftfahrtforschung*, July 6, 1938, pages 374–380, 19 illus., 27 equations.

Prospects of Propeller Drive for High Flight Speeds. G. Bock and R. Nikodemus. Efficiencies of propellers for high flight speeds are determined by calculation. Dependence of efficiency on the characteristic values of the engine (power, r.p.m. and constant-pressure height), and of the airplane (flight speed) is demonstrated. Influence of compressibility of the air on propeller efficiency, the ideal performance diagram, influence of blade number on the efficiency, consideration of profile lift/drag ratio, high-speed running of propeller tips, and propeller efficiency at high flight speeds are considered. D.V.L. report. *Luftfahrtforschung*, July 6, 1938, pages 334–339, 15 illus., 8 equations.

Induced Efficiency of the Best Propeller of Finite Blade Number. K. N. Kramer. Determination of induced efficiency of the best propeller is carried out by S. Goldstein's method for the most favorable distribution of circulation based on the Betz theorem. Required calculations for the two-bladed propeller are extended to high coefficient of propeller advance and for other blade numbers are substituted by interpolation methods. From the two diagrams derived, for conventional blade numbers and optional coefficient of propeller advance, the relation between thrust load factor (or performance load factor) and induced efficiency may be read. D.V.L. report. *Luftfahrtforschung*, July 6, 1938, pages 326–333, 9 illus., 3 tables, 26 equations.

Calculation of the Induced Efficiency of Highly-Loaded Propellers of Infinite Blade Number. F. Loesch. For the calculation of the induced efficiency of highly-loaded propellers of infinite blade number, a simple process based on a note by Prandtl is presented in a form suitable for extension to the finite blade number. Results obtained with this simple process are compared with those obtained by the Betz-Helmbold theory of the highly-loaded propeller. D.V.L. report. *Luftfahrtforschung*, July 6, 1938, pages 321–325, 5 illus., 27 equations.

Fire in Air Liners. C. G. Grey. Official records of some American pilots who brought their airplanes down while on fire are quoted and the variable-pitch propeller is acquitted of ever having set an airplane on fire. *Aeroplane*, September 21, 1938, page 335.

Miscellaneous

The Four Winds. In a flight spread over 12 days, two Soviet pilots have flown from Moscow to Vladivostock and back, a distance of over 10,000 miles, in 53 hours, 40 minutes flying time. Brief reference. *Flight*, September 22, 1938, page 256.

1938 National Air Races. C. F. McReynolds. Program of events planned for the Cleveland Races, and long discussion of pilots and airplanes entered. *Aviation*, September, 1938, pages 20–27, 77–78, 32 illus., 2 tables.

Program including aerobatic flying exhibitions of Army, Navy and civil aircraft, new Thompson race rules, and Bendix Trophy Race, is discussed. *Aero Digest*, September, 1938, pages 54–57, 3 illus.

Airplanes and pilots entered in the Bendix transcontinental race. *Western Flying*, September, 1938, page 17.

Seeing is Believing. A. F. Bonnalie. Visual instruction methods applied at the Boeing School of Aeronautics to teaching meteorology, operation of engines and parts, materials, instruments and aerodynamics. *Aviation*, September, 1938, pages 30–31, 44, 8 illus.

Aircraft Instruments

Here's What DC-4 Crews Will Look At. Photograph of cockpit of the Douglas DC-4 showing location of instruments and referring to the long list of instruments given. *Aviation*, September, 1938, page 53, 1 illus.

Kollsman's New Accelerometer. With the Kollsman Type 312 accelerometer the maintenance man may determine the exact stress to which the plane was subjected, or the maximum flight stress may be noted by the pilot and pointer reset to zero to obtain the maximum stress in landing. Maximum stress value is shown by one pointer and other pointer indicates continuously. Brief note. *Western Flying*, September, 1938, page 32. *Aviation*, September, 1938, page 48, 1 illus.

Radio Instruction in the Air. Two DeHavilland 86B 13-seater airplanes (four 200-hp. Gipsy Queen engines) will replace the elderly troop carriers hitherto used for instruction of cadets at Cranwell in practical operation of radio transmitting and receiving apparatus, blind-flying instruments and the latest R.A.E. Mark IV automatic pilot. Special features and equipment of the airplane and emergency exits are discussed. *Aeroplane*, September 7, 1938, page 300, 1 illus.

To Measure Fuel. Nivex aircraft tank gage is worked by hydrostatic pressure. Pressure required to force air out through a tube into the tank is proportional to depth of gasoline over the tube. Such pressure is supplied by withdrawing a small hand pump in the cockpit. Compensation is made for variation in outside air pressure. Few details and drawing. *Aeroplane*, August 31, 1938, page 270, 1 illus.

Bowser Device Measures Fuel Consumption. Precision instrument was specially designed to measure and record the fuel consumption of aircraft engines. It will show fuel consumption over a given period and under various load or altitude conditions or engine speeds and operates on the principle of volumetric displacement. Few details. *Aero Digest*, September, 1938, page 82.

Brief reference to Bowser Junior Xacto fuel meter. *Western Flying*, September, 1938, page 32, 1 illus.

Airplane Altimeters. M. Victor. The Dubois-Laboureur ultra-sonic altimeter is based on the same principle as the Behm sonic altimeter and is considered by the French Service Technique as the prototype of future equipment. A few details of this altimeter are given and the Behm design is discussed. The Matsuo radio-electric altimeter and the good results obtained with it in Japan are discussed. Applications of optical, sonic and electrical principles to the design of various types of altimeters are considered, and reference is made to the use of infrared rays emitted by a special projector in the nose of the airplane, point of contact with the ground being detected by a photoelectric cell in the tail. *Les Ailes*, September 15, 1938, page 7.

Detailed description of the Matsuo radio-electric altimeter. *L'Onde Électrique*, July, 1938.

Acoustics

The Reduction of Structure-Borne Noise by Vibration-Attenuating Supports. A. J. King. Application of principles to the practical case of transformer noise heard in a room adjacent to the transformer substation. Curve for calculation of equivalent loudness is shown. Concluded. *Engineering*, August 12, 1938, pages 198–199, 1 illus., 1 table.

Airports and Equipment

At the Fair's Front Door. D. Sayre. Details of the new $22,000,000 transatlantic, transcontinental airport at North Beach which is located two miles from the World's Fair grounds and 25 minutes from midtown New York. Landplane hangars will be 350 × 184 ft., having doors 165 ft. long and 40 ft. high. Seaplane hangar will have one door clearance of 204 ft. *Aviation*, September, 1938, pages 32–33, 6 illus.

San Francisco's Airports. Advantages of the locations of Mills Field and Treasure Island airport, buildings and runways at Mills Field, present administration building and hangars at Treasure Island, and plans for further conversion to an airport after the Western World's Fair. Treasure Island airport will be used by Pan American Airways in November when the new Boeing 314 Clippers go into active duty. *Western Flying*, September, 1938, pages 14–16, 4 illus.

Scales for Weighing Aircraft. Precision scales for determining load distribution as well as total weight of modern airplanes. Buffalo airplane-type scales are used in sets of three with one scale placed under each landing wheel and one under the tail skid or wheel. Few details. *Aero Digest*, September, 1938, page 85, 1 illus.

For Rapid Refueling. Thompson Mark V three-wheel refueling tender has a capacity of 500 gallons with fuel in two compartments and 50 gallons of oil. Speed of delivery is 45 gal./min. of fuel and 3 gal./min. of oil. Short description. *Aeroplane*, August 24, 1938, page 242, 2 illus.

Flare Path for Empire Flying Boats. Flares used to light the course for pilots of two Empire flying boats in taking off in darkness. Each flare consisted of two bulbs fixed to a mast mounted on top of a buoy. Current was supplied to the 18-watt lamps from a 12-volt battery contained within the buoy. Buoys were arranged in a line of six. Few details only. *Engineer*, September 30, 1938, page 351.

High-Altitude Equipment

Altitude Problems Studied. "Stratosphere" test chamber installed in United Air Lines' Chicago experimental laboratory for testing oxygenation equipment at high altitudes, performance of radio and other mechanical equipment in the substratosphere, and effects of altitude on flavor and compositions of food. Few details of test chamber. *Aero Digest*, September, 1938, page 23, 2 illus. *Western Flying*, September, 1938, page 22, 1 illus.

PX'S. Light-weight oxygen mask, developed by W. Boothby and A. Bulbulin of the Mayo Institute and recently tried out in flight at 20,000 ft., consists of a rubber nosepiece attached to a balloon lung to which oxygen is supplied through a tube from a main oxygen tank. Brief reference only. *Western Flying*, September, 1938, page 26.

Photograph only. *Aviation*, September, 1938, page 58, 1 illus.

Lighting Equipment

Spotlight. S & M landing lights mounted behind the Plexiglas nose cone of Hughes' Lockheed, one a standard leading-edge landing light, and the other a special half-million candlepower searchlight. Brief reference only. *Aviation*, September, 1938, page 48, 1 illus.

Parachutes

The Four Winds. A new automatic parachute release has been designed for use on passenger aircraft, according to reports from U.S.S.R. Mechanism can be set according to requirements and at the same time does not interfere with manual operation of the rip cord should its use be necessary. Brief reference. *Flight*, September 1, 1938, page 181.

Miscellaneous Equipment

Steam Heating for Aircraft Cabins. Gallay cabin heater is used in the DeHavilland Albatross, Handley-Page Harrow and Short Empire flying boats as well as in more modern bombers and civil transports. Latest type of boiler weighs only about 12 lb. for largest type of bomber in service and whole installation about 80 lb. including ducts. A number of tubes pass vertically through an expansion chamber on the exhaust outlet under the motor cowling. Provision is made for shutting off the heat to the cabin without losing the water in the system in form of exhaust steam. Description. *Aeroplane*, September 21, 1938, page 347, 1 illus.

Why Not? "If catapults of this sort can be set up almost anywhere to launch radio-controlled targets for coast defense gunners, why not develop a mobile catapult,—a sort of cross between a fire-escape and a tank,—to launch fighters and light bombers in war." Photograph of catapult and target airplane. *Aeroplane*, August 24, 1938, page 215, 1 illus.

Present Helps for Future Trouble. Communal type of Nissen air-raid shelter for 50 or more persons is not sunk in the ground. Building is adapted from the semicircular type of Nissen hut, made from sections of corrugated 16-gage mild steel bolted together, forming a building 30 ft. long and 7 ft. 6 in. high. Whole structure is covered with a minimum of 2½ ft. of earth. Entrance is through an air lock 6 ft. square. Description. *Aeroplane*, August 24, 1938, page 240, 3 illus.

The National Physical Laboratory. Research in the William Froude laboratory. First issue covers results of research on ship resistance, test work, and wave making, and the second those on cavitation, effect of helm action on propulsion, and paddle wheels. *Engineering*, September 16 and 23, 1938, pages 338–340 and 370–371, 1 illus.

Static Ice-Formation. Notice to aircraft owners and ground engineers on dangers of a frozen boundary layer. Brief note. *Aeroplane*, September 21, 1938, page 333.

Photography

Aerial Camera. New camera for aerial photography, developed in the Abrams Aerial Survey Corporation laboratories, carries 500 ft. of film, enough for more than 600 exposures. It has been designed to take advantage of the maximum covering power of the lens, taking pictures 9 inches square. Focal plane is set rigidly and permanently in relation to the lens, and film is held flat by vacuum pressure. Metering device insures uniform space between exposures and special attachment marks the film either between exposures or flight lines. Camera is equipped with a wide-angle 8-1/4-in. lens. Few details. *Aero Digest*, September, 1938, page 85, 1 illus.

Air Surveys Need High Speed Planes. Ideal airplane for photogrammetry must have a speed of around 200 m.p.h. and a rate of climb of 1000 ft./min. Brief reference to paper by J. Peace and short account of the meeting of the American Society of Photogrammetry, September 8–9. *Engineering News Record*, September 15, 1938, page 316.

Testing Apparatus

How Tight? Martin-Decker airplane-type tension indicator makes use of a cylinder incorporating a pressure diaphragm and a gage for transposing line load into pound gage reading. Provision is made for calibrating for temperature changes and for compensating for cables of varying sizes. Two fixed and one movable cable contact points in the base of the instrument serve to affix it to a cable for test. Few details. *Aviation*, September, 1938, page 48, 1 illus.

End-Gage Comparator of High Sensitivity. A. Turner and F. H. Rolt. Comparator designed at the National Physical Laboratory. Aim of the design was a comparator with a magnification factor at least equal to that of the larger of the two existing millionth comparators (30,000 to 1) and at the same time of such form that several block gages up to 5 in. in length could readily be stood or slid into position under the measuring head. A complete description of the mechanism of the new type of indicating head is given. Like previous high-magnification indicators designed in the Metrology Department, amplification is obtained by the combination of mechanical and optical levers. *Engineering*, August 12, 1938, pages 183–185, 9 illus.

Moving-Coil Vibrometer. G. O. Eccles. Development of a vibrometer to be used in investigations of vibration problems in buildings, and the design of a moving-coil vibrometer and the continuous recording method adopted. *Engineering*, August 26, 1938, pages 263-264, 9 illus.

The National Physical Laboratory. First issue—Research in the Engineering Department including: fluid motion and heat transmission; wind pressure on structures; silencing of motorcycles; specific heats of gases; laboratory equipment: and calibration of testing machines. Work on the alloys of iron and X-ray analysis in the Metallurgical Department is also described.

Second issue—Research carried on in the Metrology Department on engineering gages and line standards, on the refractive index of air, and on the gravitational constant. Improvements made in regard to improved accuracy of instruments combined with increased rapidity of testing are described including: the Blythswood machine for ruling diffraction gratings; machine for testing the so-called "drunkenness" of plug screws; machine for measuring pitch of large tapered screw gages; interferometer in which 18 gage blocks of different lengths up to 1 in. can be set together and their accuracy determined in terms of light waves; results of corrosion experiments to discover the effects of inclusions in steel of which the gages are made, of different methods of lapping, and of exposure to the ordinary workshop atmosphere; and measurement of surveying tapes and wires. Experiments on refraction and dispersion of air and a new absolute determination of the acceleration due to gravity at Teddington are also described.

Third issue—Research on standards of time, vibration clock, rating of watches and chronometers, barometers, and volumetric glassware. *Engineering*, August 12, September 2 and 9, 1938, pages 196–198, 266–267, and 297–299, 3 illus.

The Trend of Instrument Design. C. C. Mason. Chief developments in instrument design at the Cambridge Instrument Company, including: instruments giving 24-element records for switch-gear testing; cathode-ray oscillograph and high-speed camera for making extreme high-speed records; oscillographs for impulse testing and other applications where frequencies of several megacycles per second have to be recorded; recent developments in direct-reading voltmeters, ammeters, and wattmeters including a complete new range of dynamometer instruments of substandard grade; capacity meters of fair accuracy and quick reading, changes in design and construction of electrical instruments; dip indicator; portable electrocardigraph; physical and chemical measurements made by coupling with some other quality which, in turn, lead to direct electrical measurements; Katharometer; measurement of gases other than dilute mixtures with air; delicate micrometer for length measurements and indicating density of liquids; measurement of small changes of length by coupling the movement to the air-gap of an a.c. electromagnet; measurement of rolling-mill presses and continuous gaging of metal strip; Cambridge rolling-mill pressure recorder; and stereo comparator developed in conjunction with Ordnance Survey Department. *Engineering*, September 9, 1938, pages 317–320, 4 illus.

Materials

Automotive Materials—New Developments. Styrol and acrylic plastics are used in Pioneer instruments to take advantage of the property of transmitting considerable light edgewise to illuminate the dials of aircraft instruments in a new form of "ring" lighting. Plastic-plate nitrocellulose coating can be applied to metal, glass, molded products, and wood by the dipping method described. Electrocolor is an electrochemical process by which metallic surfaces can be colored producing color combinations of film thickness. Glass fabric base is used for Bakelite laminated material. Descriptions of the Plastic-Plate dipping method and Electrocolor process, few details of the use of glass fabric, and description of Pioneer "ring" lighting method. *Automotive Industries*, September 17, 1938, pages 353–354.

Fuels and Lubricants

Substitute Motor Fuels in France. M. Bihoreau. Possible sources of motor fuels for France. Hydrogenation processes as too expensive, vegetable oils for Diesels, production of synthetic alcohol, methyl alcohol, and use of compressed coal gas are considered. French Society of Automobile Engineers paper. *Automotive Industries*, September 10, 1938, pages 328–330, 332.

Metals

Aero-Thread Screw Systems. New type of screw fastening developed by Aircraft Screw Products Company for use particularly in materials that do not hold their threads well, such as aluminum and magnesium and their alloys. By allowance for the differences in physical properties of the steel screw and the light-alloy part Aero-Thread is said to permit full utilization of the inherent strength of the steel screw member without difficulty due to relative softness or the high thermal expansion of the light alloy. Description. *Automotive Industries*, August 27, 1938, page 261, 2 illus.

The Conception, Development, Equipment and Measuring Methods for an Entirely New Surface Finishing Method—Superfinish. W. F. Sherman. Technique of the new Chrysler Superfinish. First issue—Details of the research carried out in its development, original test data, and development of the profilometer.

Second issue—Fundamental new conceptions and definitions of terms relating to Superfinishing. Charts summarize the experience of Chrysler Corporation to date in the use of this technique as compared with conventional methods of finishing automotive parts. *Iron Age*, September 1 and 8, 1938, pages 18–23 and 40–45, 17 illus., 8 tables.

Isolating Vibration. Metalastik process of joining metal (ferrous and nonferrous, including aluminum) and rubber in such a way that joint is stronger than the rubber itself. Variation in hardness can be made to alter the degree of damping necessary for different applications and synthetic rubber can be used in instances where the component must work in oil. Propeller vibration dampers are being made for a foreign aircraft engine. Coupling is made up of two metal ellipses, the smaller concentrically inside the larger, bonded together with rubber. Reference to use in engine mounts, instrument mounting, and ball bearings. Short note. *Aeroplane*, September 28, 1938, page 394, 4 illus. *Flight*, September 29, 1938, page 289.

Tensile and shearing tests and applications briefly described. *Engineering*, September 30, 1938, page 391, 6 illus.

Machines for Airframe Production. W. G. Hunt. More important machines which have been applied to quantity production and are available in England, including: German presses; trimming, beading, and molding machines; German universal flanging, beading, trimming, and curling machine; and an American automatic punching and riveting machine. *Aircraft Engineering*, September, 1938, pages 287–289, 9 illus.

A New Method of Metal Spraying. Schori method of drawing powdered metal by vacuum from a container into a stream of compressed air so that it flows smoothly and uniformly. Gas for flame may be acetylene, butane propane, or Ferrolene. Long description. *Engineer*, September 16, 1938, page 318, 5 illus.

The Working of Stainless Steels. Behavior of three typical stainless steels to representative chemicals; methods of machining, grinding, polishing, buffing, cold working; properties of some typical stainless steels; soldering, forging, and brazing; welded joint design for stainless steels; and heat treatment of straight chromium stainless steels. An article entitled "Welding of Stainless Steels" by T. R. Lichtenwalter is included. *American Machinist*, October 5, 1938, pages 869–880, 17 illus., 3 tables.

Deep Drawing of Light Metal in Aircraft Construction. E. J. Ritter. Mechanical-technological problems in deep drawing; existing light-metal materials on hand, their investigation and testing of their capacity for deep drawing; modern drawing presses (eccentric, circular, shaft and toggle drawing presses, hydraulic drawing presses, and drop hammers); drawing tools of synthetic wood and synthetic materials, zinc, electron, and rubber; heat treatment; lubrication; and construction suggestions. *Luftwissen*, July, 1938, pages 249–255, 19 illus, 2 tables.

The National Physical Laboratory. Research in the Metallurgy Department on aluminum and magnesium, age hardening, and intercrystalline cracking, materials for use at high temperatures, oxygen in steel, temperatures of transformation of steels, miscellaneous work, and improvements in laboratory technique. *Engineering*, August 26, 1938, pages 236–238, 1 illus.

Bearings

The Tensile Stresses in a Bearing Metal Cast on to a Strip and the "Fatigue" Failure of Bearings. F. C. Thompson, A. S. Kenneford, and G. C. Seager. Experiments to determine the stresses set up in a white-metal bearing owing to the difference in the coefficients of contraction of the bearing metal and the backing material. A series of measurements were made on white metal cast on steel, brass, and aluminum strip to find if the composite bar assumed a definite curvature with the white metal, owing to its higher coefficient of contraction, on the concave side.

First issue describes the experimental procedure, variation of the coefficient of expansion of the backing metal, effect of thickness of the white metal on the contraction stress, effect of mold and casting temperatures, and effect of temperatures. It is indicated that the white metal in the bearing is in a state of tension, the stresses being of quite a high order.

Second issue shows the effect of these stresses on the life of the bearing. Cracking of metal bearings in engines appears to be due to the simultaneous effect of a tensile stress upon which is superimposed a rapidly pulsating compression. To simulate these conditions a special test apparatus was built. Results of tests with the machine are described. Importance of the nature of the backing material is very clear. A steel backing is the worst, brass, or bronze is distinctly better, while with an aluminum alloy the stress has become quite small. *Engineering*, August 26, and September 9, 1938, pages 235–236, and 295, 9 illus., 8 tables.

Plastics

Plastics Abroad. Only evidence in support of information that aircraft construction in plastic materials has reached a higher stage of development abroad than in England is that 10,000- and 12,000-ton presses are now being used to make sections of wings and parts of fuselages in Germany. Brief reference. *Aeroplane*, September 7, 1938 page 288.

Meteorology

Friez Weather Recorder. Radio-meteorographs, having a light radio transmitter sensitive to changes in air pressure, relative humidity, and temperature, are carried aloft to a height of 12 to 15 miles by hydrogen-inflated balloons. As they ascend, radio frequency signals depending upon changes in the sensitive meteorological elements in the transmitter are received by an automatic radio recorder at the airport. Few details only. *Aero Digest*, September, 1938, page 82, 2 illus.

Alpine Aerological Camp at Rochers-de-Naye. C. Schubiger. Alpine camp at 2000 meters altitude recently organized by the Swiss Federal Aviation Office and the Rochers-de-Naye physico-meteorological station. Object of the camp and research being carried out with sailplane, airplane, and radio-sounding balloons. *Les Ailes*, September 9, 1938, pages 5–6.

Engine Design and Research

Computation and Representation of Performance of the Otto-Cycle Aircraft Engine. L. Auer. Method for calculating the performance of supercharged aircraft engines. The altitude performance diagram, based on these principles, gives a good survey of the altitude behavior of an engine and can also be used for flight tests. *V.D.I.*, July 2, 1938, pages 789–793, 4 illus., 21 equations.

Durability of Hollow Crankpins with Internal Reinforcement at the Oil Bores. H. Cornelius and F. Bollenrath. A 26- to 33-percent increase in torsional strength was obtained with hollow crankpins having a ring-shaped internal reinforcement of the transverse bore, as compared with the crankpin without reinforcement. Effect of the double-duro hardening on the torsional strength apparently depends on the tempered strength of the steel in the initial condition, tempered test pieces showing a slight increase and hard-tempered test pieces a considerable reduction of the strength.

Further tests will be made on case-hardened test pieces since previous tests yielded extraordinarily low strength values. Tests are to be continued with test pieces hardened by the double-duro-Tocco method. By suitable control of the heating period an attempt will be made to prevent the reduction of strength by surface hardening in the case of high-tempered steel.

Report covers results of tests on reinforced and plain hollow crankpins of case-hardened chrome-nickel-molybdenum steel, carbon steel with small vanadium content, a nickel-free chrome-molybdenum steel, a low-alloy chrome-molybdenum nickel steel, and one of higher alloy content, as well as of steels hardened by the double-duro method. D.V.L report. *V.D.I.*, July 23, 1938, pages 885–889, 19 illus., 2 tables.

The Installation of Radial Engines in Aircraft. R. Eisenlohr. It is demonstrated that, regardless of the highly advanced design of radial engines, great development is still possible in the design, construction, and installation of power plants in the airplane. Table gives characteristics of the following air-cooled radial engines: Bramo Sh 14A and Fafnir; Alfa Romeo RC34; Fiat A-74 RC-38 and A-80 RC-20; Gnôme-Rhône M-14. N-14 and L-18; Hispano-Suiza AA-79 and AB-80; Piaggio XI RC-50; Pratt & Whitney Twin Wasp and Wasp Junior; Wright R-1500 Whirlwind; and Bristol Hercules. *A.T.Z.*, July 25, 1938, pages 375–377, 5 illus., 1 table.

Slide-Valve Controlled Internal Combustion Engines. Riedel. Survey of piston displacement performance possible in engines using slide valves instead of poppet valves. Bristol-Nevatt plain slide valves, Baer cylinder slide valves, Cross cylinder slide valves, Aspin conical valves, and Sklenar spherical slide valves are described in detail. Long article. *A.T.Z.*, July 10, 1938, pages 340–351, 48 illus., 1 table.

Definitions for Aircraft Engines. F. A. F. Schmidt. New standard definitions for aircraft engines including performance, average operating pressures, fuel consumption, efficiency, r.p.m., characteristic values of the gas exchange processes, excess air quantity, and weight. Special definitions for superchargers also given. *Luftfahrtforschung*, July 6, 1938, pages 368–373, 10 tables.

Effect of Altitude of Flight on the Cooling of Aircraft Engines. T. Helmbold. Change of atmospheric conditions and physical properties with altitude adversely influence the transfer of heat from aircooled engine cylinders. Effects of these changes on heat transfer for various altitudes of flight were investigated. Change of heat transfer with flight altitude is determined by calculation of conditions existing at that altitude at different cooling air speeds and wall temperatures (10° to 250°C.). Cooling conditions required for a constant indicated engine output particularly are established. The author shows how large the fin spacing should be at the determined altitudes, instead of at ground conditions, in order that no mutual boundary layer influences will arise. Report of the B.M.W. aircraft-engine company. *Luftfahrtforschung*, July 6, 1938, pages 354–367, 20 illus., 1 table, 27 equations.

Modern Poppet Valve Problems. E. Wood. Metallurgical aspects affecting valve design, and results of a study of valve failures. Corrosion is probably the chief cause of fatigue failures in exhaust valves. Author considers that the cracks start in the intermediate layer of partially oxidized steel between the scale and the core of the homogeneous steel.

Discussion includes: a high-chromium high-nickel austenitic steel of British Air Ministry specification (D.T.D. 49B) and its disadvantages in engines using heavily-leaded fuels; serious embrittlement of high-chromium austenitic steel after exposure to temperatures above 600°C. and other drawbacks; types of exhaust-valve failures; material defects; D.T.D. 282 valve steel considered not susceptible to embrittlement but equal in resistance to scaling and strength at high temperatures; disadvantages accruing from complex building up of the valve as shown by interdendritic unsoundness in the Stellite coating applied to the seat; faulty forging and defective material as promoting blow-piping; and fatigue failures. *Aircraft Engineering*, September, 1938, pages 282–284, 289, 9 illus., 2 tables.

The Two-Cycle Engine with Unsymmetrical Control Diagram. J. Zeman. Mathematical fundamentals are given in an attempt to establish a component problem of two-cycle engine construction. Application of the mathematical method assumes a knowledge of the scavenging curve. Establishment of these curves under various conditions is one of the most urgent requirements of two-cycle engine construction. Discussion and calculations cover: pressure distribution in the cylinder during scavenging; determination of the amount of scavenging air; stationary or dynamic treatment of the scavenging process; scavenging and loading; exhaust slot measurement; scavenging mixing apparatus; pressure distribution during scavenging for insufficiently regulated exhaust; and crankcase apparatus. Long article. *A.T.Z.*, August 25, 1938, pages 420–434, 18 illus., 4 tables, 39 equations.

A New Way of Reducing Point-Burning of Sparking Plugs. F. R. F. Ramsay. The K.L.G. BR.90 Elbow Register of 1000 ohms is illustrated and its development is described. Reasons for erosion of spark plugs, how the spark occurs, effects of capacity, and efforts to nullify them are discussed. *Aeroplane*, August 3, 1938, pages 145–146, 5 illus.

Steam Condensation—Effect of Tube Position. H. T. Quigg, W. C. Moyer, and R. L. Huntington. Overall coefficients were obtained on a single-tube steam condenser placed in horizontal, 45°, and vertical positions, and nature of different types of condensation was observed through a Pyrex glass jacket enclosing the steam space. At slower flow rates, effect of tube position is negligible but at higher Reynolds numbers overall coefficients for the 45° and horizontal tube positions were approximately 25 to 50 percent higher. *Industrial and Engineering Chemistry, Ind. Ed.*, September, 1938, pages 1047–1051, 3 illus., 2 tables.

Engine, Fuel, and Lubricant Testing

Bench Testing of Carburetors. W. C. Clothier. Methods of bench testing are described in detail, and particular problems in the determination of the mixture characteristics of aircraft carburetors are considered. Discussion covers: effect of separation from the engine; a typical test plant for a wide range of test conditions, including air and fuel flow measurements, fuel pressure control, method of overcoming freezing troubles, and a pneumatic vibrator used; test procedure in regard to quantities to be measured; tests for new types and production type carburetors; typical test results and effect of pulsating air flow; and special tests for freezing, jets, effect of temperature, tilting, catapulting, and atomization. Long article published with permission of the British Air Ministry. *Aircraft Engineering*, September, 1938, pages 274–281, 14 illus.

D.V.L. Exhaust-Gas Analyzer for Internal-Combustion Engines. H. H. Berg. From direct readings of the indicator of the exhaust-gas analyzer the most desirable and economic setting for the fuel mixture can be determined during flight. Analyzer was developed by the D.V.L. in cooperation with the Hartmann and Braun Company and is suitable for investigations of aircraft and automotive engines as well as for test stands and other stationary installations. It is universally applicable due to easy handling, great accuracy, and independence of exhaust-gas composition and engine construction and operation. It is also useful as an auxiliary means in estimating heat output, especially of Otto-cycle engines. With the analyzer it is possible to use rich mixtures at high loads, especially in aircraft engines, without dangerous temperatures and detonation. Short description of device. *A.T.Z.*, September 10, 1938, page 455, 2 illus.

A Mechanical-Optical High-Speed Indicator. S. G. Bauer. Method of producing separate records of individual engine cycles which was developed in the Cambridge University Engineering Laboratories. Indicator pressure element consists of a tube rolled to the shape of a flat twisted strip which has the property of untwisting under internal pressure. Recording of the torsion of the indicator element is done optically and records evaluated under a traveling microscope. Only angular rotation around the longitudinal axis of the tube, which is due to internal pressure, is recorded. Long description of indicator pressure element, optical recorder, and indicator camera. *Engineer*, August 19, 1938, pages 196–198, 6 illus.

A New Type of Torsiograph. K. Schwaiger and K. Boger. D.V.L. torsiograph described makes use of the principle that the electrical resistance between a carbon disc and a metal support varies with the pressure between the two. Metallic plunger is carried on an arm secured to the forward end of the crankshaft. Two lines are traced on the record, one a curve of torsional vibration whose ordinates are measures of the amplitude of that vibration, and the other containing division points equal to one crankshaft revolution. Abstract from *A.T.Z.*, July 25. *Automotive Industries*, September 24, 1938, page 370, 2 illus.

An Oil and Bearing Testing Machine. "Admiralty" testing machine, made by Sir W. H. Bailey and Company, is designed for carrying out tests on bearings and journals in various metals, and for recording the behavior and qualities of oils and greases under varying loads, speeds, temperatures, and types of bearings. Speed range is from 239 to 3800 r.p.m. and a maximum pressure of 35 kg./sq.cm. or 27,000 kg. total load can be applied on the test bearing. Total number of revolutions and coefficient of friction are recorded and on test head are a combined indicator and recorder for temperature and speed. Description. *Engineer*, August 19, 1938, pages 209–210, 2 illus.

Problem of Detonation Measuring Methods. F. Lichtenberger and F. Seeber. Long series of tests at the D.V.L., begun by A. v. Philippovich, indicated that the dp/dt measurement yielded insufficient differences and for this reason a second differentiation was made. Measurement of the d^2p/dt^2 was made by a quartz indicator, the pressure curve of which could be differentiated electrically by introduction of a choke coil. This differentiation is only accurate for a limited amplitude and frequency range. Outside of this range the choke coil no longer acts as pure inductivity.

A second differentiation by series connections of two amplifier steps leads to inaccurate results. The first differentiation was undertaken directly at the entrance circuit of the amplifier by a new connection which also has the advantages of a much lower insulation resistance of 10^8 ohms. Apparatus and test results discussed. Report of the Institute of Fuel Research and Engine Construction of the D.V.L. *A.T.Z.*, July 25, 1938, pages 372–374, 3 illus.

Electric Test Installations Used in the Development of Aircraft Engines. E. Loetterle. Electric test stands for high-speed aircraft engines, particularly the special construction adopted in high-speed d.c. test balances. In torque stands connections with regenerative braking are preferred and special locking switches have been developed for test stands to give increased security to the service crew and engines. For current supply for large installations the central transformer has been found most suitable.

Electrical installations for single-cylinder tests, for engine-development tests, for high-altitude tests, for supercharger tests, and for tests of engine accessories are described. Photograph shows the brake unit for an aircraft-engine test stand housed with accessories in a streamlined support in the wind tunnel, including three test balances with brake output of 3600 hp. at 1200 to 3300 r.p.m. Drawings show a wind-tunnel test layout for aircooled engines, electrical arrangement for the high-altitude test stand, and electrical diagram for the single-cylinder test stand. *E.T.Z.*, July 7, 1938, pages 709–714, 6 illus.

Electrical Apparatus for Measuring Torsional Vibration. K. Schwaiger and K. Boger. Electrical vibration indicator developed by Dr. Geiger and the D.V.L. produces a new type of vibration diagram and leads to conclusions as to different stress conditions of the crankshaft so far assumed (uneven amplitude). When irregularities occur in the operation or torsional oscillation of high-speed shafts this indicates that angular acceleration develops which, in connection with a mass, can be used for the disintegration of forces according to the law $F = Ma$. These normally periodically varying forces can be converted into electric current fluctuations and by the conventional oscillograph observed directly and recorded. Description of apparatus and results of tests indicating that friction dampers yield better results than rubber dampers. *A.T.Z.*, July 25, 1938, pages 369–372, 9 illus.

Friction in Oscillating Bearings. A. Fogg and C. Jakeman. Frictional characteristics of a journal bearing subjected to oscillating motion under different conditions of load, temperature, and frequency of oscillation, and the effect of different lubricants upon the friction. A modification of the apparatus designed by Sir Thomas Stanton, which was used in the experiments is described and test results discussed.

Friction depended on other characteristics of the lubricant than its viscosity, and as frequency increased there was a considerable reduction in the friction. At a frequency of one cycle per minute the apparatus seemed capable of giving approximate values of the coefficient of kinetic boundary friction, and at high frequencies provided a means of classifying lubricants in order of oiliness. Abstract of Lubrication Research Technical Paper No. 3, National Physical Laboratory. *Engineering*, August 5, 1938, page 170.

Engines

The Cirrus Midget. New 50-hp. four-cylinder inline air-cooled engine develops a maximum of 55 hp. at 2600 r.p.m., 45 hp. for take-off and 49 hp. at 2300 r.p.m. for initial climb. Fuel consumption should be about $2^1/_2$ to $2^3/_4$ gal./hr. at cruising and 2730 the maximum permissible diving r.p.m.

Description. *Flight*, September 22, 1938, page 261, 4 illus. *Aeroplane*, September 21, 1938, page 345, 3 illus.

For Stratosfaring. Swedish Lindequist inverted-vee 12 engine with underhead camshafts is designed for use in the stratosphere and produces from 900 to 1200 hp. according to varied accounts. Engine appears to be liquid-cooled and length of cylinders is unusual. Brief reference to rumors about the engine. *Aeroplane*, August 24, 1938, page 231.

High Ratings for Daimler Benz. Medium supercharged version of the Daimler-Benz D.B. 600 inverted-vee twelve engine gives 1050-hp. for take-off, and this is also the rated power of the fully-supercharged unit at 13,120 ft. Weight of the medium supercharged model is 1200 lb., the altitude blower adding 45 lb. Short description with the new power figures. *Flight*, September 22, 1938, page 264.

Putting Up Power. Napier Dagger VIII 24-cylinder aircooled H airplane engine has a maximum permissible output, for five minutes, of 1000 hp. at 8750 ft., and has been given an International Rating of 890/925 hp. at 4200 r.p.m. at 900 ft. Improvements include larger double-entry supercharger, increased fin area for cooling, complete ignition screening, provision for a DeHavilland-Hamilton constant-speed propeller, S.U. carburetor with automatic mixture control, and electrically energized inertia starter. Performance and a few details only. *Aeroplane*, August 3, 1938, page 156. 1 illus.

Aeroplane Engine Replacement. In cooperation with German engine makers and the Deutsche Lufthansa, the firm of Junkers is making an effort to standardize airplane engines and mountings to effect rapid replacement. In a recent test, three engineers replaced individual engines on a Junkers Ju. 90 in 20 minutes with assistance of a mobile crane. Aircraft had landed, had the engines changed and was in the air again within a half hour. Brief reference. *Engineer*, September 2, 1938, page 253.

The BMW 132-Dc Aircraft Engine. BMW 132-Dc 9-cylinder radial supercharged aircraft engine designed for continuous power at 4750 meters. Full power output is 945 hp. for 1 minute for 2.0 km. and 655 hp. for 3.8 km. Long description, performance curves, and photographs of supercharger and other parts. *Luftwissen*, July, 1938, pages 262–264, 5 illus., 2 tables.

Engines for Hampden and Wellington. Bristol Pegasus XVIII 9-cylinder, aircooled radial engine with two-speed supercharger giving 980 hp. at take-off is to be introduced into the Service in the Handley-Page Hampden and Wellington twin-engined bombers. Sleeve-valve Hercules and water-cooled Merlin are alternatives in the Wellington. Crankcase cowl with louvres, as popularized in America, will be standardized on the Wellington but not on the first of the production-type Hampdens. Brief note on engine performance. *Flight*, September 15, 1938, page 228.

Four Thousand Horses. New American heavy-oil aircraft engine, according to rumor, is intended to give 4000 hp. and will drive oppositely-rotating propellers. As there will be one propeller at each end of the engine it seems to be intended for the new airship. It is reported that the engine "will give its maximum output when working as a two-stroke but will be allowed to four-stroke for normal cruising, so that there will then be only half the number of working strokes." Brief reference. *Aeroplane*, August 31, 1938, page 265.

New A T C for Menasco. Menasco C6S-4 6-cylinder aircooled inverted inline engine has a displacement of 544.9 cu. in. and is rated at 260 hp. at 2300 r.p.m. at 7500 ft, with a take-off rating of 290 hp. at 2400 r.p.m. Few details. *Western Flying*, September, 1938, page 20.

Operating Experience with Junkers Aircraft Engines. Dr. Stuessel. Practical experience of Deutsche Lufthansa airline with heavy-oil engines. Discussion covers: Reasons for putting the Diesel engine in service; piston troubles experienced with the Jumo 204 and 205 and their elimination in later models; hours flown with these engines and number of active engines used in Deutsche Lufthansa 1931 to 1937; and performance of the Dornier Do-18 and Blohm and Voss Ha-139 seaplanes on the Atlantic service. Long abstract of paper and details of the record flight of the D-ANHR Dornier flying boat over 5200 miles from England to South America. *Engineering*, September 9, 1938, pages 315–317, 4 illus., 3 tables.

A Swedish Stratosfarer. Lindequist aircraft engine designed to give 1000 hp. at 1800 r.p.m. at 12,000 to 18,000 meters. Supercharger has to supply 430 cubic meters of air per minute. Photograph only. *Aeroplane*, September 7, 1938, page 290, 1 illus.

Two Cycle Engine with Pneumatically-Controlled Scavenging Slot. French Ragoucy engine with pneumatically-controlled scavenging slots. Cross-sectional drawing and short description. The Coatalen 12-cylinder vee 550-hp. Diesel engine is described in a second short article with a drawing of the automatic injection nozzle used. *A.T.Z.*, July 25, 1938, page 381, 1 illus.

PARTS AND ACCESSORIES

Longer Life for Piston Rings. Bricoseal is a special chemical treatment for piston rings to make the surface porous and capable of absorbing oil. It gives a surface layer just thick enough to last until the running-in stage has been finished. Few details.

Second note describes the Aero Multivent oil-scraper ring which has an annular groove around the circumference in which there are a number of slots. Bottom land or flange of the ring has a number of recesses placed between the slots and milled to the depth of the annular groove. *Aeroplane*, September 21, 1938, page 355, 1 illus.

A Variable Gear for Aero Motors. Carter hydraulic transmission and fluid dynamometer for aircraft engines is intended to combine the qualities of a variable-speed gear, a vibration damper, and a dynamometer. With the variable-speed gear the engine can be run at constant speed with a fixed-pitch propeller and full power can be absorbed at take-off. An oversized propeller can be used to give good performance higher up without destroying that lower down. Transmission consists of a train of epicyclic gears controlled by oil under pressure which varies with r.p.m. *Aeroplane*, September 21, 1938, page 346, 1 illus.

Aircraft Radio

A Short-Wave Cathode-Ray Direction Finding Receiver. By Staff of the Radio Research Station, National Physical Laboratory. Improved receiver with cathode-ray-tube visual indicator, was designed and constructed for use with a short-wave spaced-aerial direction finder. Essential circuit arrangements are described together with precautions taken to secure equality of performance of the dual amplifiers incorporated in the receiver. Direction of the trace on the cathode-ray tube indicator can be read to an accuracy of about 2°, and sensitivity of the receiver is such that this accuracy may be utilized when input to grid of first valve is not less than 50 u *V*. *Wireless Engr.*, August, 1938, pages 432–439, 8 illus.

3 Spots and a Horn. D. G. Fink. In the blind landing system developed at M.I.T. for the Bureau of Air Commerce and based on I. Metcalf's "three-light" method, the glide path is a straight line and independent of changes in the reflecting properties of the ground surface. Two overlapping regions will be established by four beams, one for vertical and one for horizontal directivity, and will intersect each other at right angles along a line corresponding to the landing path. On the aircraft indications of the artificial horizon and gyro compass are transferred electrically to the face of a cathode-ray tube, where they appear together with the indications of the glide-path receiver. Pilot observes these three points and, by visualizing the reference plane as passing through them, he is enabled to make a landing entirely independent of direct visibility of the airport surface. Very long description of the Metcalf three-light system, W. L. Barrow's method of propagating extremely short radio waves, the proposed system, horn radiator, operation of the cathode-ray tube, and control of the spots from the gyro instruments. *Aviation*, September, 1938, pages 28–29, 73–74, 3 illus.

Aero Radio Digest. Douglas DC-4's elaborate apparatus for radio communication and navigation was designed by Bell Telephone Laboratories, and built by Western Electric Company, and uses 800-cycle power supply from the airplane's independent motor-generators. Long description of this equipment and shorter descriptions of the Radio Frequency Laboratories' Model B-3 miniature radio-range beacon receiver of the 5-tube superheterodyne type, radio trainer developed by the Boeing School of Aeronautics for classroom demonstration of the operation of the aural radio ranges, and Lear electrical remotely-controlled motor-driven antenna loading coil. *Aero Digest*, September, 1938, pages 70, 73, 5 illus.

Automatic S.O.S. First issue—Easton automatic radio distress-signal transmitter, after starting work, will repeat a distress call for three days. Transmitter is a small two-valve transmitter working on a 5-meter wavelength and was designed by an English physicist. It is housed in the tail of the aircraft, insulated against shocks and surrounded by asbestos. Few details.

Second issue—Wrightson distress-call transmitter is a two-valve transmitter with an electrically-driven drum which, in contact with suitably placed studs, causes a distress signal and call sign of the airplane to be transmitted. Outer case is so designed that if the aircraft becomes waterlogged, the instrument floats free and still operates. Set also operates if undercarriage should break or engine stops with ignition on. Description. *Flight*, September 1, and 15, 1938, pages 184a and 241, 1 illus.

Aviation Radio. D. Fink. Radio equipment of the DC-4 airplane which includes a 250-watt transmitter and four receivers. Description of this equipment, few details of the Lear motor-driven antenna loading unit and references to the following: Aeronautical Radio Company "Ear-Saver" for pilots (filter device connected between the phone jack and the phones); Carter genemotor having a maximum output of 500 volts at 200 ma. and weighing 10 lb.; and Triumph Cone Oscillator model 255 for modulation of beacon transmitters and blind landing systems. W. F. Nicol's loose-leaf data on radio-range stations in the United States also referred to. *Aviation*, September, 1938, pages 42–43, 6 illus.

Needed Regulations in Aircraft Radio. H. W. Roberts. Improvements proposed include: extension of ATC requirements to embrace all aircraft radio; stricter requirements for aircraft radio Approved Type Certificates dealing with performance characteristics of radio apparatus as well as physical properties of aircraft radio materials; development of new testing technique and testing apparatus; and adoption of suitable Letters of Competency for installation and maintenance of aircraft radio. *Aero Digest*, September, 1938, page 81.

Device Shows Dispatchers Direction of Incoming Planes. Device determines for the aircraft dispatcher at the airport the direction from which an approaching airplane's radio transmitter is sending signals and provides for indications on any 10 wave lengths which may be selected remotely. As each pilot talks to the control tower at his destination, a spot of light waves moves instantly to its correct position on the screen of a cathode-ray tube. Points of the compass are marked around the screen's edge. Few details of device developed by Bell Telephone Laboratories. *Science News Letter*, September 24, 1938, page 199.

Remote Controlled Inductance. Electrical remote-controlled motor-driven antenna loading inductance for use where a small fixed antenna is required to be tuned to a wide range of frequencies for transmitting purposes. Few details. *Western Flying*, September, 1938, page 32.

Aeronautical Industry and Production

Company Activities. Recent activities of Aeronca, Beech, Consolidated, Curtiss-Wright, Fairchild, Grumman, Lockheed, Menasco, Norma-Hoffman, Pacific Airmotive, Piper, Ryan, Vega, Vultee, and Waco companies. News of new companies formed includes Brewster Aircraft Parts, Aviation Castings, Gyro Aircraft Engines, and Cooper-Wilford Berylium, Ltd. *Aero Digest*, September, 1938, pages 21–22, 1 illus.

Exports Reach $37,121,659. During the first six months of the current year, aeronautic exports attained this total value which, compared with $16,290,580 for the same period last year, represents a gain of 128 per cent. Expert business in June was 205 per cent above June, 1937, and 1.5 per cent over May, 1938, and included 93 airplanes and 112 engines. China accounted for $2,066,235 for 42 airplanes and 17 engines and $252,800 worth of parts and accessories. Japan bought $1,863,983 worth of equipment including 15 airplanes and 12 engines. Russian purchases at $1,497,297 included 3 airplanes and $1,120,347 worth of parts and equipment. *Aero Digest*, September, 1938, pages 35–36, 1 chart.

Short note. *Western Flying*, September, 1938, page 20.

Production Increases. Aircraft and aircraft-engine sales increased by 47 percent during the first six months of 1938 when deliveries were made totaling $73,031,816 as compared with $49,450,114 during the same period last year. Military aircraft deliveries totaled 717 units valued at $29,285,927 and 1135 engines valued at $8,526,914. Brief note. *Aero Digest*, September, 1938, page 20. *Western Flying*, September, 1938, page 18, 1 table.

Status of Aircraft and Pilots by States as of July 1, 1938, in the United States. Table of statistics. *Western Flying*, September, 1938, page 30.

Trade Still Set Fair. British exports of airplanes, airships, balloons and parts are still increasing, figures for July being £471,573. Figures for seven months to July and for July, 1936–1938 are given. Brief reference. *Aeroplane*, September 7, 1938, page 301.

Pilots

Altitude Flight. Lt. Col. M. Pezzi. Test results obtained in the Division of High-Altitude Flight in Italy. Physiological research on the effects of high altitudes on lung ventilation, blood, heart, and nervous system and psychic activities is described. Investigations were made in normal air, with the addition of oxygen, and with the addition of oxygen-carbon dioxide mixtures. Abstract of paper presented before the Lilienthal-Gesellschaft in 1937. *Luftwehr*, July, 1938, pages 274–276, 2 illus.